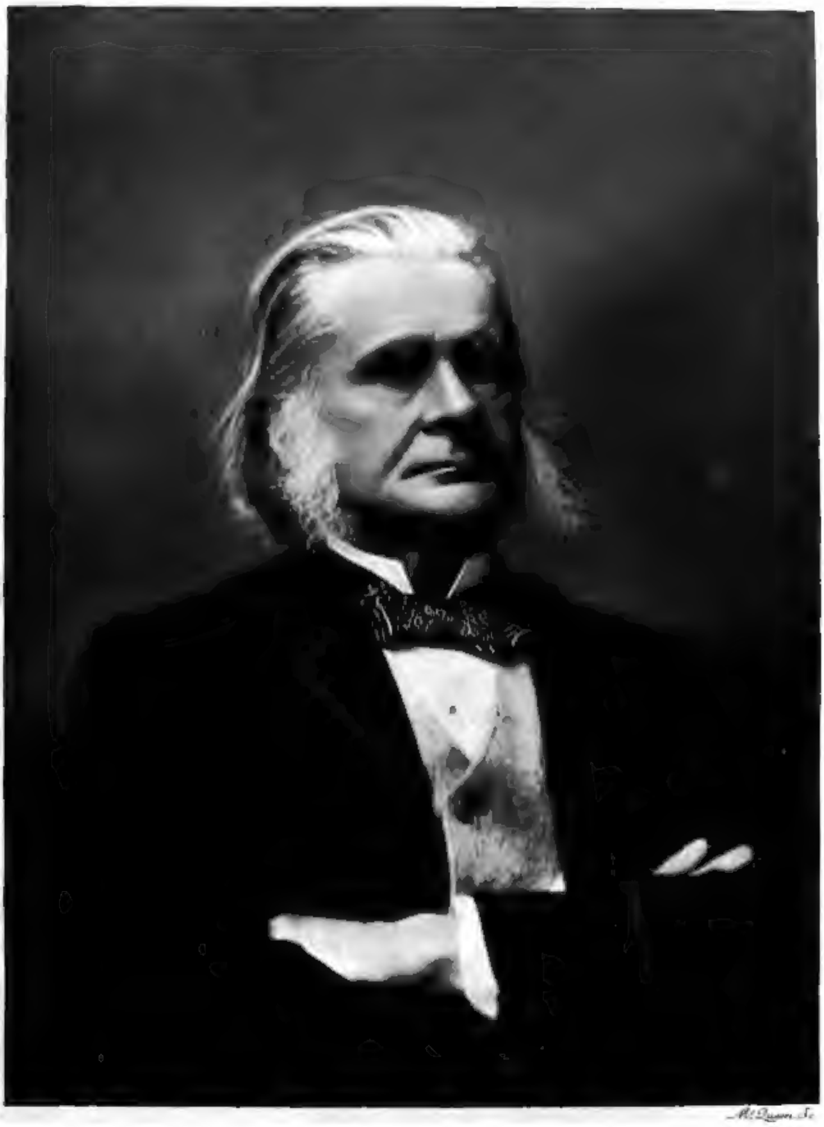
THE SCIENTIFIC MEMOIRS

OF

THOMAS HENRY HUXLEY



T. H. Huxley.

From a photograph by Mayall, 1893.

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THOMAS HENRY HUXLEY

EDITED BY

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The less complete fragments of skulls distinguished by the specific name of *planirostris* were procured at Antwerp during the excavation of some docks.

As the figures show, and as Cuvier expressly states in the text, the "posterior wall of the nostrils," even in the more perfect of the two specimens of this species, is so mutilated that no judgment respecting its true form can be arrived at; and as the posterior part of the solitary specimen called *Ziphius longirostris* (of unknown origin) is equally deficient, it follows that the only positive character (apart from the close resemblance to *Hyperoödon*) attributed to the genus by Cuvier—the overhanging posterior wall of the nostrils—cannot be predicated, with certainty, of two of the three species included in it.

In 1846, Professor Van Beneden[1] published a note upon two fossils obtained during the Antwerp excavations, of which one exactly resembled the *Ziphius planirostris* of Cuvier, whilst the other was like *Z. longirostris*, but had the advantage of being more complete than Cuvier's specimen, the distal end being preserved.

'The end of the snout is much produced, and terminates in a very acute point. Towards the middle of its length it is compressed, and its height is almost double its width. These dimensions, on the other hand, hardly differ at its extremity."

After noting the differences between this specimen and the foregoing, Professor Van Beneden observes:—

"These differences indicate modifications of sufficient importance to lead us to suppose that these animals cannot belong to one and the same genus, and that, instead of a species, we have here a new genus."

Cuvier appears to have considered his *Ziphius* to be an extinct genus; but many attempts have since been made to refer existing species to it. Thus, at p. 26 of the 'Zoology of the Erebus and Terror' (Parts III. IV. & V., "Mammalia," 1846), Dr. Gray observes:—

"*Physeter bidens* (Sowerby) has been referred to this genus [*Hyperoödon*]; but the form of the head and the position of the fins, the teeth and the form of the skull, show it is a *Ziphius*."

But neither the form of the head, nor the position of the fins, nor the teeth of any species of Cuvier's *Ziphius* are known with certainty; so that Dr. Gray's reference of the *Physeter bidens* of Sowerby thereto must have been based upon the form of the skull only. The only Cuvierian *Ziphius* the skull of which is well

[1] Bulletin de l'Académie Royale de Belgique, tom xiii. 1° partie, p. 257.

the palatine rugosities of the Bottlenose are sufficient to bear out the name; and even were it otherwise, the expediency of altering well-established generic names, on account of some error in their signification, appears to me to be very doubtful.

Professor A. Wagner had already proposed to distinguish *Delphinus micropterus* subgenerically under the name of *Micropterus*. This name Eschricht modifies, on etymological grounds, into "*Micropteron*," and concludes thus:—

"The fossil *Rhynchoceti* have hitherto all been called *Ziphius*; very probably, fuller knowledge will oblige us to range them in one of the two genera which are still living, viz. *Micropteron*. The name *Ziphius* should, probably, therefore be regarded only as a temporary one, unless, if the fossils should be identified generically with recent forms, the older Cuvierian name of *Ziphius* should be preferred to the new one."

Dr. Gray identifies *Ziphius* generically with the living *Physeter bidens*; and Professor Eschricht, it will be observed, substantially agrees with him, inasmuch as he ranges Sowerby's Dolphin in *Micropteron*. M. Gervais, in his "Mémoire sur la Famille des Cétacés Ziphioides," published in the 'Annales des Sciences Naturelles' for 1850, brought forward a new series of considerations, tending to refer *Ziphius* to a recent type; and as M. Gervais entertains the conviction that no living species of mammal existed during any Tertiary epoch, his identification of Cuvier's *Ziphius cavirostris* with the living Mediterranean species of Cetacean stranded at Aresquiers, in the Department of Hérault, in May 1850, led him to dispute the truly fossil character of *Ziphius cavirostris*. M. Gervais justly draws attention to the differences between *Ziphius cavirostris* and the two other Cuvierian species, and indicates what he conceives to be the close analogy of *Ziphius longirostris* with the recent *Delphinus densirostris*, which he ranges in a distinct genus, under the name of *Dioplodon*.

At the same time he establishes the genus *Mesoplodon* for Sowerby's Dolphin; and he combines all these genera, namely, *Ziphius*, *Dioplodon*, and *Mesoplodon*, with *Hyperoödon*, into the family of *Cetacea Ziphioidea*.

But, as M. Gervais agrees with Eschricht in identifying Sowerby's Dolphin with *Delphinus micropterus*, he was bound to adopt Eschricht's name, *Micropteron*, instead of inventing a new one (*Mesoplodon*) to cover the same group; and, similarly "*Cetacea Ziphioidea*" can only be regarded as a synonym of "*Rhynchoceti*" and "*Hyperoödontinæ*."

In the 'Annales des Sciences' for 1851, M. Duvernoy made

But if the line of argument taken by M. Duvernoy is a correct one, and "*Ziphius*" *longirostris* is generically identical with *Delphinus micropterus*, then it is a *Micropteron* (Eschricht). On the other hand, if *Delphinus densirostris* has a claim to generic distinctness from *D. micropterus* and *D. Sowerbiensis*, as would seem to be the case, M. Gervais's name of *Dioplodon* must stand, and the question arises—is "*Ziphius*" *longirostris* a *Dioplodon*?

I am acquainted with the skull of *Dioplodon densirostris* only by the figures given by MM. Duvernoy and Gervais, there being no specimen of this rare animal in England, to my knowledge. But these figures clearly show (1) that the width of the vomer exposed on the upper face of the snout does not nearly attain one-third the whole width of that face, and (2) that the vomer terminates before reaching the end of the rostrum, the premaxillæ being separated beyond it by a well-marked notch or cleft, so that the end of the snout is bifid, as in Cetacea in general.

Now, in all the fossil rostra allied to "*Ziphius*" *longirostris* which I have examined, or seen figured, the vomer occupies fully a third of the width of the upper face of the rostrum; and in the few instances in which the extremity of the rostrum is entire, it is not bifid, but sharply pointed, almost like the end of the guard of a Belemnite, the vomer and premaxillæ seeming to coalesce into one solid terminal cone.

Taking into account these marked differences from any recent species, observable in the structure of the beaks of the fossil forms, and considering that we know nothing whatever of the mandibular dentition of the latter, I think they should be regarded as members of a distinct genus, to which the name of *Belemnoziphius* may be applied. And were there not, as I believe there are, sufficient zoological grounds for this step, I might urge as a palæontological argument in its favour, the great importance of not passing over too lightly any differences which may be observable between the Mammals of the Crag and those of the present day.

Up to this time only two species of *Belemnoziphius* have been described, *B. longirostris* (*Ziphius longirostris*, Cuv.) and *B. Becanii* (*Dioplodon Becanii*, Gervais and Van Beneden). In the British Museum, however, there is a fine collection of rostra belonging to Cetaceans of this genus, which have been named by Professor Owen *Ziphius angustus*, *Z. gibbus*, *Z. declivus*, *Z. angulatus*, *Z. planus*, and *Z. undatus*. Though, in the absence of any published description of these forms, the names have no authority, I should have been glad to adopt one of them for the species of which I am about to give an

account, had any of the British Museum specimens appeared to be specifically identical with it. This, however, is not the case, and therefore I propose to confer upon the new specimen the name of *Belemnoziphius compressus.*

BELEMNOZIPHIUS COMPRESSUS, sp. nov. Pl. XIX. [Plate I.] figs. A, B, C, D.

The fossil in question was obtained by George Tomline, Esq., M.P., from a quarry upon his estate, on the edge of "Blackheath," three miles east of Ipswich in Suffolk, which has been worked for the so-called "Coprolites"; and which, I am assured by Sir R. I. Murchison, is situated in the Red Crag.

The specimen is very heavy, and has the characteristic aspect of Crag fossils. It would appear to have lain at the bottom of the sea for some time before fossilization, as its surface is covered with superficial hemispherical pits, apparently *Pholas*-borings.

The singular density of the bony structure of the snout of the ancient Dolphin readily accounts for the relatively little wear and tear which it has undergone, and for the small success of the animals which attempted to tunnel it.

The specimen is 14·8 inches long, and is broken at both ends. Anteriorly it is flattened from side to side, and much deeper than wide; posteriorly, on the other hand, it is flattened from above downwards, and wider than it is deep. Its whole upper face is convex from side to side; but the convexity is but little marked posteriorly, where the upper face ends, at the junction of the upper and middle thirds of the depth of the bone, in a well-defined lateral ridge. The section of this part of the rostrum is a sort of triangle, with the base turned upwards. The lateral ridges descend as they pass forwards, until, about the middle of the length of the specimen, they are situated opposite the middle of its depth; beyond this point the direction of each ridge is continued by a well-marked groove, which already exists as a canal underneath the ridge, and opens on the fractured hinder extremity of the specimen. As the lateral ridges die away anteriorly, and the rostrum becomes more flattened from side to side, its section acquires a vertically elongated oval outline. Posteriorly the upper contour is slightly convex, and then sweeps, with a slight concavity, to its distal third, which has a well-defined upward convexity.

Inferiorly and anteriorly the longitudinal contour is convex; but in its posterior third it is sharply concave. The anterior third of the

inferior surface is smooth, flattened, and triangular, the apex of the triangle being directed backwards. The hinder third of the inferior surface, rough and irregular, doubtless gave attachment to the palatine bones. It is separated by a curved shoulder-like projection, which fades away anteriorly into a slight linear depression, from the smooth lateral surface of the rostrum.

The upper face exhibits a central area, about 1 inch wide, and bounded by the well-defined parallel grooves, which end posteriorly in short covered ways. These terminate in the front walls of two canals (*aa*), which open above by somewhat funnel-shaped rounded apertures, looking a little backwards as well as upwards. The canals lead from these apertures, at first downwards and a little forwards, and then turn sharply backwards, to become much wider, and terminate on the posterior face of the specimen. Between these canals the same face exhibits a large and deep fossa.

About 2¼ inches in front of the upper apertures of the canals the "central area" exhibits the commencement of a slit (*b*), which deepens as it passes backwards, and becomes lost in an irregular fossa. The slit is not perfectly central or symmetrical. The left face of the specimen is more complete than the right. It exhibits the two grooves, ending behind in canals already mentioned, and the third slighter groove, which is continuous with the curved flange, or shoulder, against which the palatine bone fitted.

On the right side a good deal of the bone is broken away from the posterior half of its lateral face, and the canal under the ridge is laid open. About three-quarters of an inch below it there is another canal of the same size, and running parallel into the foregoing, which is filled with hard ferruginous matrix. It opens posteriorly on the palatine flange.

The ends of two canals, which would seem to be distinct from either of these, are seen in the middle of the fractured distal end of the specimen (fig. D).

It is probable (as Duvernoy has already pointed out) that the "central area" indicates the upper extent of the vomer, the only remains of its primitive trough-like cavity being the median slit above and the large fossa behind. Into the latter the remains of the cartilaginous ethmoidal septum doubtless fitted.

The lateral ridges, with the grooves, which continue their direction downwards and forwards, define the outer and lower margins of the premaxillæ in which the curved canals are situated; and between these ridges and grooves, the flange, and the sulcus into which it passes, the surface of the rostrum probably appertains to the maxilla.

that genus and *Choneziphius planirostris* are derived from the English or Antwerp Crag, and are not known to occur out of it.

4. So that at present we are justified in regarding *Belemnoziphius* and *Choneziphius* as true Crag mammals.

Since the preceding pages were in type, Professor Van Beneden has had the goodness to send me his interesting and valuable memoirs, "Sur une nouvelle Espèce de *Ziphius*" and "On *Mesoplodon Sowerbiensis*," published in the 'Bulletin' of the Belgian Academy for 1863, which had not reached me at the time these pages were written.

The new "*Ziphius indicus*" appears to be very closely allied to the Cetacean of Aresquiers, which Professor Van Beneden agrees with M. Gervais in identifying with Cuvier's *Z. cavirostris*. In the course of his memoir on this species, Professor Van Beneden refers incidentally to two other Ziphioid Cetaceans of new generic types—"Ziphirostre" and "Placocète"; the former of which had already been mentioned as the "*Dioplodon* of Hemixem" in a notice published by M. Van Beneden in the tenth volume of the second series of the 'Bulletin.' On referring to the page of that volume cited, I find, unfortunately, no statement of the distinctive characters of the *Ziphirostrum*; and the description of *Placocetus* also is not yet published.

EXPLANATION OF PLATE XIX. [PLATE I.].

Rostrum of *Belemnoziphius compressus*, one-third the natural size, viewed—A, laterally; B, from below; C, from above D, the anterior fractured end.

[PLATE I]

Quart Journ. Geol. Soc Vol XX. Pl XIX

M&N Hanhart

BELEMNOZIPHIUS COMPRESSUS. (*Huxley.*)

II

ON THE STRUCTURE OF THE BELEMNITIDÆ; WITH A DESCRIPTION OF A MORE COMPLETE SPECIMEN OF *BELEMNITES* THAN ANY HITHERTO KNOWN, AND AN ACCOUNT OF A NEW GENUS OF BELEMNITIDÆ, *XIPHOTEUTHIS*.

Memoirs of the Geological Survey of the United Kingdom. Figures and Descriptions illustrative of British Organic Remains. Monograph II., 1864.

THE fossil shell called *Belemnites* consists fundamentally of (1) a hollow cone, the *phargmoconus*, with a thin, shelly, wall which may be termed the *conotheca*, and which is divided by transverse *septa*, more or less convex towards the apex of the cone, and concave towards its base, into chambers, or *loculi*. Each septum is traversed, close to the *conotheca*, in a direction which corresponds with the median ventral line of the body, by a canal, the *siphunculus*. More or less extensively enveloping the apical part of the phragmocone is (2) a more solid body, the guard, or *rostrum*, composed of calcareous matter arranged in prisms, or fibres, perpendicular to the planes of lamellæ. These are disposed concentrically around an axis, the so-called *apical line*, which extends from the extremity of the phragmocone to that of the rostrum.

All observers are agreed as to the presence of the parts hitherto mentioned in a Belemnite, but a great diversity of opinion prevails respecting the nature, and indeed the existence, of a third constituent of the fossil, the so-called "pen" or "osselet." As the part which commonly goes by the name of "pen" in the Belemnite, however, corresponds to only a part of the structure already known as the "pen" in recent *Cephalopoda*, I shall endeavour to avoid ambiguity, by using for it the apellation of *pro-ostracum*.

In a paper "On the discovery of a new species of Pterodactyle, and also of the fæces of the Ichthyosaurus, and of a black substance resembling Sepia or Indian ink, in the Lias of Lyme Regis," read

before the Geological Society, on the 6th February 1829, by Dr. Buckland, the following passage occurs.

"3. *Fossil Sepia.*—An indurated black animal substance, like that in the ink-bag of the cuttle fish, occurs in the Lias at Lyme Regis; and a drawing made with this fossil pigment, three years ago, was pronounced by an eminent artist to have been tinted with sepia. It is nearly of the colour and consistence of jet, and very fragile, with a bright splintery fracture; its powdér is brown, like that of painters' sepia; it occurs in single masses, nearly of the shape and size of a small gall-bladder, broadest at the base, and gradually contracted towards the neck: these are always surrounded by a thin nacreous case, brilliant as the most vivid Lumachella; the nacre seems to have formed the lining of a fibrous, thin, shelly substance, which, together with this nacreous lining, was prolonged into a hollow cone like that of a belemnite, beyond the neck of the ink-bag; close to the base of the ink-bag there is a series of circular transverse plates and narrow chambers, resembling the chambered alveolus within the cone of a belemnite; but, beyond the apex of this alveolus, no spathose body has been found.

"The author infers that the animal from which these fossil ink-bags are derived, was some unknown cephalopod, nearly allied in its internal structure to the inhabitant of the belemnite; the circular form of the septa showing that they cannot be referred to the molluscous inhabitant of any nautilus or cornu-ammonis."

This is, so far as I am aware, the first notice of the existence of a pro-ostracum in a Belemnite.

Voltz, writing in 1830, had no direct knowledge of the existence of any such structure, though he was led by observation of the lines of growth of the conotheca, to conclude that it was prolonged dorsally; but, in the same year, Count Münster[1] published descriptions and figures of *Belemnites* with complete pro-ostraca.

"In the Belemnites there is an empty prolongation, similar to the last open chamber, of the guard, which is as long as the thick and chambered shell, but infinitely more delicate, as in the Orthoceratites, and hardly of the thickness of the skin of a bladder."

The species which exhibited this pen in the best state of preservation was *Belemnites semisulcatus*, complete specimens of which, from the Solenhofen slates, are represented in Count Münster's third and fourth figures.

[1] "Nouvelles Observations sur les Bélemnites, in Boué's Mémoires Géologiques," translated from "Bemerkungen zur näheren Kenntniss der Belemniten."—4to. Baireuth, 1850, p. 296.

Dr. Buckland returns to the subject in his "Bridgewater Treatise" (1836), page 374, note.

"In 1829, I communicated to the Geological Society of London a notice respecting the probable connection of Belemnites with certain fossil ink-bags, surrounded by brilliant nacre, found in the Lias at Lyme Regis. (*See* Phil. Mag., N.S., 1829, p. 388.) At the same time I caused to be prepared the drawings of fossils engraved in Plate 44″, which induced me to consider these ink-bags as derived from Cephalopods connected with Belemnites. I then withheld their publication, in the hope of discovering *certain* demonstration, in some specimens that should present these ink-bags in connection with the sheath or body of a Belemnite, and this demonstration has at length been furnished by a discovery made by Professor Agassiz (October 1834), in the cabinet of Miss Philpotts, at Lyme Regis, of two important specimens which appear to be decisive of the question. (*See* Pl. 44′, figs. 7-9.)

"Each of these specimens contains an ink-bag within the anterior portion of the sheath of a perfect Belemnite; and we are henceforth enabled with certainty to refer all species of Belemnites to a family in the class of Cephalopods for which I would, in concurrence with M. Agassiz, propose the name of *Belemnosepia*.[1] Such ink-bags are occasionally found in contact with traces of isolated alveoli of Belemnites; they are more frequently surrounded only by a thin plate of brilliant nacre."

In his statement of the component parts of a Belemnite (l. c., p. 372), Dr. Buckland very clearly defines the characters of the part which he had discovered; it is, says he, "a conical, thin, horny sheath or cup, commencing from the base of the hollow cone of the fibro-calcareous sheath, and enlarging rapidly as it extends outwards to a considerable distance. Pl. 44′, fig. 7 b, e, e′, e″. This horny cup forms the anterior chamber of the Belemnite, and contained the ink-bag (c) and some other viscera."

In Dr. Buckland's restoration of the "Belemnosepia," Pl. 44′, fig. 1,

[1] Buckland, it is obvious, proposes *Belemnosepia* as a name for the animal, or 'family' of animals to which the shell called "Belemnite" belongs, and not as a name for the particular specimens which he examined. Those who have considered these specimens not to belong to the family of the *Belemnitidæ* at all, therefore, but to the *Teuthidæ* or *Loligidæ*, are not justified in using *Belemnosepia* as a generic title—for the intention of the authors of that name is to employ *Belemnosepia* as the equivalent of *Belemnites* in its ordinary acceptation; and as naturalists have refused to do so, and continue, as I think, wisely, to use "*Belemnites*" for the genus of animals which fabricate the shell called "Belemnite," *Belemnosepia* remains as a mere synonym, and can be employed in no other sense.

the cup in question, or pro-ostracum, *e*, *e*, is made to extend nearly to the anterior end of the mantle of the animal.

In the preceding year (1835) Professor Agassiz communicated a short note, "Ueber Belemniten," to Leonhard and Bronn's "Jahrbuch," in which he states that "he has made out with certainty that the so-called *Onychoteuthis prisca* with the ink-bags, as they are figured by Von Zieten (as Loligo, Tab. XXV.), are nothing but the anterior prolongation of a Belemnite, and, indeed, of *B. ovalis*, as is shown by a perfect specimen from the Lias of Lyme Regis, in Miss E. Philpotts's collection. "The Belemnites have, therefore, the plate of *Onychoteuthis*, as a prolongation of the alveolus, and, internally, the ink-sac of *Sepia*."

We shall find reason to believe, however, that what Von Zieten figures in the plate referred to are pens of *Loligidæ*. And it must be particularly observed that Agassiz and Buckland, though apparently in agreement, are not really so. Dr. Buckland neither assents to the proposition that the pens figured by Von Zieten belong to Belemnites, nor does he agree with Professor Agassiz's opinion that Miss Philpotts's specimens exhibit traces of such a pen.

In the paper entitled "Bemerkungen über das genus Belemnosepia und über den fossilen Dinten-sack in den vorderen Kegel der Belemniten," in fact, Buckland speaks of Von Zieten's specimens as "species of Loligo" (p. 39, note), and in the Bridgewater Treatise, p. 308, when treating of the pens and ink-bags of "Loligo" in the English Lias, he says,—

"We learn from a recent German publication (Zieten's Versteinerungen Wurtembergs, Stuttgart, 1832, Pl. 25 and Pl. 37), that similar remains of pens and ink-bags are of frequent occurrence in the Lias shales of Aalen and Boll."

Taking for granted the correctness of Professor Agassiz's interpretation of the pen called "*Onychoteuthis prisca*," as the pro-ostracum of *Belemnites ovalis*, M. Voltz contributed much towards the acceptance of that interpretation by essaying to prove (Ueber *Onychoteuthis prisca* von Münster; Leonhard und Bronn's Jahrbuch, 1836, p. 323), that the arrangement of the lines of growth in the former corresponds with that of certain striations upon the conotheca of Belemnites to which he had drawn particular attention in his "Observations sur les Belemnites" (1830). These are two systems of very remarkable striæ visible on the outer surface of the lamellated test composing the conotheca: "the one kind are straight and set out from the apex, they are analogous to the longitudinal striæ of all univalve and bivalve shells; and the others are more or less transverse." The

first set are usually well seen only in the ventral or internal face. "Commonly, the external lamina of the conotheca shows them more distinctly than the internal laminæ, whilst the other striæ are seen equally well on all the laminæ. These last indicate the mode of its progressive growth, and, consequently, the form which the opening had during the whole period of its growth.

"These striæ of growth form a series of transverse semicircles, parallel with the sutures of the septa, on the ventral face of the phragmocone. There are always many on each alveolar chamber, and they are the closer together the nearer they are to the apex. This arrangement is seen only on the ventral face of the phragmocone; and when the striæ reach the lateral regions they assume an almost hyperbolic curvature to approach the straight lines which pass from the apex of the cone and run, between the side and the back, as far as the aperture. I shall call these lines the *asymptotes*, and the lateral regions where the striæ have a hyperbolic curvature, *hyperbolic areæ* (régions hyperboliques); the region between the *asymptotes* I shall term the *dorsal area* (région dorsale). The transverse striæ sometimes unite in groups into a single line, when they take the hyperbolic curvature and ascend towards the asymptote. The width of the dorsal area, that of the hyperbolic areæ, the quantity and the curvature of the striæ of these different areæ, vary according to the species; but this variation is very slight. The width of the dorsal area is usually about one-fourth of the circumference, and that of each of the hyperbolic areæ an eighth.

"The striæ of the dorsal area are less numerous than those of the rest of the test, and are usually less pronounced than the latter, being sometimes imperceptible; they form ogive arcs, the apex of which is turned towards the aperture of the shell. Often, one sees a slightly raised straight line, which sets out from the apex of the cone and intersects the summits of all the ogives; at other times a groove traverses the region; and occasionally the ogives are not visible.

"It would appear from these facts that the ventral edge of the aperture of the phragmocone is parallel to the sutures of the septa, and that, on the sides, it curves round almost at a right angle to form an elongated lobe, which terminates in an ogive arch on the dorsal side."

The existence of these *conothecal striæ* has been noted by all observers, and Voltz's clear description of their distribution and direction has been largely confirmed. I shall have to point out, however, that one species of Belemnite, at any rate, exhibits a different pattern.

The view taken by Agassiz and Voltz of the nature of the Liassic pens, formerly referred to *Loligo* and *Onychoteuthis*, met with strong opposition in an essay by Prof. Quenstedt, entitled "Loligo Bollensis ist kein Belemniten Organ," and published in Leonhard and Bronn's Jahrbuch for 1839.

Prof. Quenstedt points out, with great justice, firstly, that the markings on the pens are quite different in character from those on the phragmocones of any known Belemnites; and, secondly, that the posterior ends of the pens are complete, and certainly were not united with any such structure as a Belemnite, while it is impossible to imagine that the latter should have been attached to the anterior ends of the pens.

In 1840, however, M. Voltz, in his "Observations sur les Belopeltis ou lames dorsales des Bélemnites,"[1] brings forward new arguments in favour of Agassiz' opinion.

In the first place he gives a clear view of the structure of Belemnites in general, repeating and extending his previous statements, and more especially defining his opinion as to the meaning of the conothecal striæ.

"As the striæ of growth represent the successive openings of shells, one is always enabled to form an exact idea of the form of a shell at any stage of its growth, when the whole length of these striæ is followed out, so that an exact idea of the form of the opening of the conotheca (test alveolaire) of a Belemnite may be formed by following one of the lines of growth."

Voltz gives a restoration of the Belemnite shell constructed upon this principle in the third figure of the third plate of the work cited.

The Liassic and Oolitic pens are, for M. Voltz, the pro-ostraca of *Belemnites*; but as these Belemnites are unknown, he proposes for them the new generic name of *Belopeltis*. In anticipation of obvious objections, M. Voltz writes :—

"It might be supposed that the *Belopeltes* belong to some other genus of Cephalopods than *Belemnites*, or than any other known form of Acetabulifera; and the shell of which, though without a guard, had much analogy with the alveolar test [conotheca] of the Belemnite. But then one would ask why these *Belopeltes* are always incomplete at their apices, a fact which is fully explained, and, so to speak, becomes a necessity, when these fossils are referred to *Belemnites*. It would also be necessary to explain why no fossils are ever found which can be referred to the apex of *Belopeltis*, and why, lastly, fossils are never met with appertaining to the dorsal lobe of the alveolar test of Belemnites; a very much elongated lobe, the existence of which in

[1] Mémoires de la Société d'Histoire Naturelle de Strasbourg.—June 1840.

entire and uninjured Belemnites cannot be doubted by any one who has carefully examined the striæ of growth of the alveolar test [conotheca] of the Belemnites." L.c., p. 21.

And further, in his "Observations Supplémentaires" (l.c., p. 31):—

"M. Buckland gives, on his Plates 44′ and 44″, figures representing fragments of Belemnites found at Lyme Regis and still containing the ink-bag. The figure 7, Plate 44′, represents *Belemnites ovalis* with its ink-bag.

"It is to be regretted that M. Buckland has not published a figure of the counterpart of this specimen; for M. Agassiz, who studied this very important fossil in 1834 or 1835, and who discussed it at length with M. Buckland, says, in the German translation of the Bridgewater Treatise, that the counterpart of the fossil exhibits the dorsal region of the alveolus with striæ similar to those which are seen in Plates 28, 29, and 30 of this work,[1] so that not the smallest doubt could be entertained as to the justice of the union of *Belopeltis* with *Belemnites*, a union the necessity of which was made obvious to my friend, M. Agassiz, by his first inspection of the fossil.

"M. Buckland states in his work that the specimen presents a nacreous test showing transverse and waved striæ. M. Agassiz says, on the other hand, that he does not comprehend this explanation, and that these striæ are the traces of the sutures of the septa with the alveolar cone. The mere inspection of the figure suggests the same idea, for these striæ appear to be more marked than simple striæ of growth would be, and they are placed at relative distances which correspond well to the intervals between the alveoli of Belemnites, and which are too great to be striæ of growth. If this be the case, it evidently follows that the ink-sac is not in its natural place, since it occupies that of the septa, which would be impossible.[2]

"M. Quenstedt has just published, in Leonhard and Bronn's Jahrbuch, a memoir, the intention of which is to prove that the *Belopeltes* do not belong to Belemnites. He gives, in this memoir, the figure of a *Belopeltis*, which does not appear to me to be exact, because it represents the fracture which is always observed at the posterior part of these fossils, not as a fracture, but as the commencement of the shell; this would then be the point from which the successive growths which formed the shell started. M. Quenstedt had the goodness, in August 1839, to show me, in the museum of the University of Tübingen, the

[1] "Pen and ink-bags of Loligo" are represented on these plates.

[2] It would be interesting to know what the striæ seen upon the counterpart by Professor Agassiz really were, and why Dr. Buckland nowhere says anything about them. I suspect that they were the conothecal striæ.

original of this figure, but I was unable to agree with him on this point. The striæ of growth of this fossil present no point that can be considered as the origin of the shell; the asymptotes and the hyperbolic striæ can be very well observed cutting transversely the lines which this naturalist takes for the origin of the shell; therefore the part of the shell whence its growth emanated, was inevitably situated beyond that line. The origin must have been at the point of union of the two asymptotes, and the shell is necessarily incomplete at its extremity. Now the whole theory of M. Quenstedt is based on this obviously erroneous mode of interpreting the fossil, so that it cannot be admitted."

In 1842, M. D'Orbigny, Paléontologie Française, Tome 1er, p. 41, and Planches II., III., IV., described with much confidence, and figured, what he terms the "osselet corné" of the Belemnites.

"It varies but little in form, as I have been enabled to judge by the examination of more than 15 distinct species, the rostra of which are very different, while I have always found it to have the same configuration. It is composed, in front, of a broad spatuliform plate exhibiting, in the middle, a wide dorsal region [1] (*a*, Fig. 1, Pl. IV., et 3, Pl. III., the part comprised between the lines *b*, *b*), the angle of which always exceeds ten degrees, covered with ogive-like striæ of growth, which unite on each side at the median line, which is sometimes projecting or slightly grooved.

"On each side of the dorsal region are the lateral expansions [2] which pass from this region and form, on each side, delicate horny plates, which are marked with lines of growth passing obliquely from above downwards, and from the dorsal to the ventral face. These expansions accompany the "osselet" through its whole length (*see* Pl. III., fig. 2, Pl. IV., fig. 1, the parts which lie between the lines *c*, *d*), and diminish in width from above downwards as far as the inferior part, where they form a longer or shorter conical cup, which appears to constitute about a third of the whole length. On the sides, at the point of junction of the lateral expansions with the terminal cup, the lines of growth suddenly become sinuated, form curves with a downward convexity, and become transverse in the whole ventral region, to give rise to the terminal cup, a kind of reversed horny cone, in which the chambers are developed successively as the animal grows."

It appears, however, (*see* p. 43 of the work cited) that all this

[1] The *Asymptotes* of M. Voltz's Memoir, p. 3.

[2] It is these lines, convex when the cone is reversed, which form what M. Voltz calls "hyperbolic regions."

elaborate description of the "osselet corné" is not based upon the examination of a specimen of any such structure, but that it is deduced from the character of the markings upon the surface of the phragmocone originally described by Voltz. In point of fact D'Orbigny made no real addition to the discoveries and conclusions of the latter excellent observer.

Quenstedt (Die Cephalopoden, p. 389) agrees with Voltz in the description of the lineations of the sheath of the phragmocone, but declines to deduce thence the existence of a pen. Making no distinction between the views of Buckland and those of Agassiz, and continuing to deny the existence of evidence justifying the connexion of such pens as those of *Loligo Bollensis*, with *Belemnites*, he falls into the error of doubting Buckland's identification of the nacreous pro-ostraca, &c. of Lyme Regis with Belemnites; and, after a critical examination of *Belemnites semisulcatus*, he is disposed to admit, at most, "that the shell of the Belemnite alveolus (= phragmocone) did not end superiorly by a circular lip, but in a unilateral parabolic process, which can by no means be safely compared to a true Loligo pen."

M. Duval Jouve ("Bélemnites des Terrains Crétacés Inférieurs," 1841), observed no pro-ostracum attached to any of the specimens he studied.

In describing the specimens upon which he founded the genus *Belemnoteuthis*, in the "Proceedings of the Geological Society" for 1842, Mr. Channing Pearce indicated the existence of a "*sepiostaire*" in that genus, in addition to the phragmocone and guard.

Professor Owen, in his memoir "On the Belemnites" (Phil. Trans., 1844), having mistaken *Belemnoteuthis* for *Belemnites*, describes the rudimentary rostrum of the former as the conotheca of the latter: with regard to the existence of a pro-ostracum in Belemnites generally, he follows Dr. Buckland (l.c., p. 66).

In 1848, Dr. Mantell (Observations on Belemnites, &c., Philosophical Transactions) gave a more complete account of the pro-ostracum of a Belemnite (*Belemnites attenuatus*) than had previously appeared. In describing the specimen figured in his Plate XV., fig. 3, he writes,—

"This fossil comprises the following parts:—1. The capsule or *periostracum*. This external investment (c^1, c^1, c^1), which consists of a thin, shelly, or corneo-calcareous integument that closely embraces the guard, and, gradually enlarging upwards, finally surrounds the peristome of the phragmocone, constituting the thin horny laminated sheath or receptacle (c, c), has been described by all previous

observers as an extension of what they termed the sheath, or capsule; within this receptacle the ink-bag and other viscera were probably contained * * * * * * *
The phragmocone enlarges upwards, and anteriorly to the siphonated part constitutes a large chamber, from the margin of which are produced two or more long, upright, shelly or calcareous processes, as shown in Pl. XV., Fig. 3*b*, *b*[1]."

In a subsequent memoir[1] Dr. Mantell shows that there were but two of these processes, that they were situated nearer the dorsal than the ventral aspect of the phragmocone, and that they were continued downwards into "nacreous bands or plates, finely striated" upon the outer surface of the chambered cone.

As I have already indicated, Quenstedt (Die Cephalopoden, 1849) discusses the question of the presence or absence of a pen in the Belemnites at great length, without arriving at any decided result; and Bronn (Lethœa, dritte Auflage Bd. II., 1851–2) increased the confusion which had already spread over the subject, by following Quenstedt in his scepticism respecting the truly Belemnitoid character of *Belemnoteuthis*, and by referring the *Belemnosepia* of Buckland to the family of the *Loligidæ* and the genus *Belopeltis*. At least he does this at p. 407 of the work cited, while at p. 385 he seems to entertain a different opinion:

"The animal of the Belemnite is perfectly unknown; what Buckland, Agassiz, and R. Owen say of it must be referred to *Belemnoteuthis*, which only on account of accidental juxtaposition has been taken for a part of a Belemnite. Of an ink-bag also no trace is ever seen."

That the specimens described by Professor Owen as the animals of the *Belemnite* are *Belemnoteuthes*, as Pearce, Cunnington, and Mantell demonstrated, admits of no doubt, and has since been acknowledged by Mr. Owen ("Palæontology," p. 113), and that Agassiz was in error in identifying Von Zieten's *Onychoteuthis prisca* with a Belemnite, also seems to be clear; but Buckland is in a totally different position, and it will be seen that his interpretation of the Lyme Regis specimens was in the main correct.

Of the pro-ostracum (hornige Dute) Bronn says that "it has never been found entire, and rarely in a substantive form, but its composition must be judged by combining fragments and their lines of growth." In fact he essentially adopts Voltz's view of its structure and extent.

[1] On the structure of the Belemnite and Belemnoteuthis.—Philosophical Transactions, 1848.

Professor Quenstedt's final opinions appear to be stated in his "Handbuch der Petrefakten-kunde" (1852). After describing the conothecal lines, he says (p. 385), "It is but rarely that all these markings are distinctly visible, and especially they do not agree with those on the pen (schulpe) of the parabolic Loliginites, as was for some time wrongly asserted, and as some still maintain. On the other hand, they indicate the end of the conotheca (alveolarschale), as it has long been known from Solenhofen, and has been lately figured by Mantell, also from the Oxford clay at Trowbridge in Wiltshire (Philosophical Transactions, 1848). From two corresponding specimens, which I have lately obtained from Solenhofen, the fig. 13 of plate 31 is constructed of half the natural size. The conotheca (A) is chambered up to its upper part, but when the chambers cease, the lip also ends upon the ventral side, as it seems by a horizontal boundary, which would answer to the horizontal lines, *b*, upon the conotheca of *B. giganteus.* Dorsally, on the contrary, a high parabolic shield extends, at the edges of which two sometimes deeply coloured bands, *h,h*, are clearly perceived, and end in points like sharp ears superiorly. These are the hyperbolar regions, which, where they bend down below from the margin, have quite the same curvature as in *Belemnites giganteus.* Between these horns lies the region of the dorsal curves, *a,a*, with a median line *r*, in which the lines of growth are plainly curved upwards, just as the free margin of the shield is."

Professor Quenstedt's observations thus clearly confirm those of Mantell, and go to prove that some Belemnites have a two-ribbed pro-ostracum ; but he is, as we shall see, in error in supposing that all *Belemnites* have a pro-ostracum like that of his specimens ; and still more in his assumption (p. 333) that *Belemnoteuthis* has no phragmocone, and is not one of the *Belemnitidæ,* but an *Onychoteuthis.*

Professor Pictet ("Traité de Paléontologie," 1854) follows D'Orbigny (or rather Voltz) as to the pro-ostracum of Belemnites, and with Bronn separates *Belemnosepia* from the *Belemnitidæ,* while, on the other hand, he is inclined to admit *Belemnoteuthis* as a distinct genus of the last-named family.

Mr. S. P. Woodward (Manual of the Mollusca, 1851) states that the "Pen" of the Belemnites is "represented by the nacreous bands on the dorsal side of the phragmocone, and produced beyond its rim in the form of sword-shaped processes (Pl. II., fig. 5)." From this description and the reference to the figure of *Belemnites Puzosianus* from the Oxford clay (= *B. attenuatus,* Mantell), it is clear that Mr. Woodward conceives that the pro-ostraca of Belemnites, in general, are constructed upon the type of that of *B. Puzosianus.*

Mr. Woodward identifies *Belemnosepia* with *Geoteuthis*, and therefore refers Buckland's specimens to the *Teuthidæ* and not to the *Belemnitidæ*. In his Supplement, published in 1856, the same author writes (p. 449),—

"*Belemnites.*—Professor Buckman of Cirencester possesses a phragmocone from the Lias, containing the fossil ink-bag."

Professor Owen (Palæontology, 2nd ed., 1861, pp. 111, 112), in speaking of the remains of "Calamaries (Teuthidæ)," states that "the most common form of the gladius has the shaft wide and longer than the wings; it has a nacreous lining, and is usually accompanied by a large and well-preserved ink-bag (Geoteuthis, fig. 34, 4). These were called *Belemnosepia* by Agassiz and Buckland, who supposed them to belong to the same animal with the Belemnite."

But I am not aware that any one has yet observed a calamary's "gladius" with a nacreous lining; and we have seen that Buckland entertained no such opinion as that here ascribed to him.

Belemnoteuthis is identified with Münster's *Acanthoteuthis*. Of the Belemnites, Professor Owen, adopting Dr. Mantell's results, says, "The last chamber is rarely preserved, and appears to have thinned off into a mere horny sheath with, sometimes, two pearly bands, like knife-blades on the dorsal side. It must have been sufficiently capacious to contain all the viscera. The ink-bag has been very rarely found, and is even smaller than in the last genus, as if in relation to the more generally developed shell."

From the preceding survey of the literature of the subject it appears that very diverse opinions obtain respecting the nature and character of the pro-ostracum in *Belemnitidæ*.

1. According to Dr. Buckland, this part is a corneous, or shelly, and more or less completely nacreous, extension forwards of the lip of the phragmocone.

2. According to Agassiz, it is a "pen" identical with that of the so-called *Loligo Bollensis*, &c.

3. According to Voltz, it is a pen analogous to that of *Loligo Bollensis.*

4. According to Mantell and Quenstedt, it is a broad dorsal plate, more or less corneous in the middle, and with two strong calcified asymptotic bands.

Furthermore, as to the existence of specimens proving that the Belemnite was provided with an ink-bag; some, like Buckland and Woodward, affirm the fact as a matter of direct observation; others support the conclusion that the ink-bag existed in *Belemnites*, by the analogy of *Belemnoteuthis*; while yet others, denying *Belemnoteuthis*,

or Buckland's Liassic specimens, to belong to the *Belemnitidæ*, doubt the existence of any direct, or conclusive indirect, evidence of the existence of this organ in the *Belemnitidæ*.

So with regard to the acetabular hooks and beaks: that such structures appertained to *Belemnoteuthis* was proved by Pearce and Cunnington and by Professor Owen; but, at present, I am aware of no direct evidence of their existence in *Belemnites*.

These lacunæ in our knowledge of one of the most important of extinct forms of life are filled up by the specimens described in the present Memoir, which demonstrate the accuracy of Dr. Buckland's view of the nature of the Lyme Regis fossils figured in his Plates 44′ and 44″; and furthermore, prove that at least three types of structure of the pro-ostracum must be distinguished among the *Belemnitidæ*.

Some time ago, my friend Mr. Day of Charmouth was good enough to direct my attention to a number of remarkable specimens of *Belemnitidæ* obtained from the Lias in his neighbourhood, and now either in his own possession, or in that of the Rev. Mr. Montefiore and Mr. Henry Norris, gentlemen to whom I am greatly indebted for the readiness with which they have entrusted valuable and important fossils to me for examination and description.

The most complete Belemnite in existence, to my knowledge, is that specimen, the property of the Rev. Mr. Montefiore, which is represented in Plate I. [Plate 2], fig. 1. Mr. Day informs me that it was obtained from the *Ammonites obtusus* zone of the Lower Lias near Charmouth.

In this remarkable fossil not only are the guard, phragmocone, and pro-ostracum preserved, but the general contour of the body is shown, the beak is in its place, and irregular lines of hooks indicate the position and extent of the arms.

The length of the whole animal, from the summit of the beak to the apex of the guard, is 12½ in., while its greatest breadth does not exceed 1¾ inches. The arms, as indicated by the lines of hooks, cannot be traced for a distance of more than 1½ in. from the beak, and they diverge from one another, so as to include a triangular space, the broad base of which is superior, while its apex is close to the beaks.

The internal shell is 11·8 inches long, and consists of guard, phragmocone and pro-ostracum. The guard and the phragmocone occupy rather less than the half of the whole shell (5·5 in. about). The guard, about 0·3 in. thick in the middle, and nearly circular in section, remains of about the same diameter for 1½in., widening, above, into the alveolus for the phragmocone, while, below, it tapers to the apex.

The inferior narrowing commences at about half an inch from the apex, which is marked by five indistinct, short, longitudinal grooves. Superiorly, the guard spreads out over the phragmocone, becoming gradually thinner, and ceasing to be traceable, as guard, at the point (*d*), about 2¾ in. from the apex.

The guard is broken at the points *b* and *c*; at *b* the surfaces correspond perfectly, but at *c* there is a slight loss of substance, so that the portion of the guard *a*, *c*, may not be in quite its natural position relatively to the rest. I am inclined to suspect that there has been some slight shifting of position at this point, from the circumstance that the curved contour of the right side of the guard is somewhat more convex than that of the left side, while the whole guard is slightly flattened in the plane of the surface of the matrix. The right contour should therefore be ventral, and the left dorsal. But there can be hardly any doubt that the upper face of the body of the specimen is the dorsal aspect, so that it would appear that the guard, where broken at *c*, has undergone a certain twist upon its axis.

The primary chamber of the phragmocone probably lies in the guard about the point indicated by the letter *x*. For the two lateral margins of the phragmocone, if produced, would meet thereabouts; and furthermore, while at the line of fracture, *c*, the diameter of the phragmocone is nearly equal to that of the guard, the latter forming a layer not more than $\frac{1}{16}$ in. thick round it, at *b*, the guard is solid throughout. Where the guard ceases to be traceable on the phragmocone at *d*, it is 0·75 in. broad, and the phragmocone gradually widens, until at *e*, the furthest point to which it can be traced, it is 1½ in. broad. It must be recollected, however, that these dimensions are exaggerated by the crushing and flattening of the specimen.

From *e* to *f*, a distance of 2¼ in., the pro-ostracum is represented by a delicate lamella of shelly substance, for the most part exhibiting a beautiful nacreous lustre, and as wide as the upper diameter of the phragmocone. The central part of this lamella is blackish, with metallic reflections, and its edges are constricted in the middle, so that it appears saddle-shaped. At the sides it passes into a lamina of yellow nacre (*h*), which dips down towards the ventral side of the body, and is traceable, on the right side, as far as the point (*h'*). Beyond this, no remains of any shelly matter are distinctly visible, but the surface of the matrix exhibits an irregular impression, extending as far as (*i*), as of a thin, broad, partially crushed, oval extension of the pro-ostracum. I presume that the mantle of the animal also terminated at this point. Beyond it, the impression of the head is indistinctly traceable; and it is worthy of note that the head seems to have been small as compared

with the size of the body. The oral circle, embraced by the bases of the short, uncinated, arms (*l*), is particularly narrow, so that these bases are closely approximated. What was the precise number of the arms, and whether any long tentacles did or did not exist cannot be ascertained.

The remains of the beak (*k*), about half an inch long by 0·4 in. wide, are so crushed and broken that there is some difficulty in the way of interpreting the appearances it presents. I believe, however, that the two beaks are fractured transversely, the dorsum of the dorsal beak, and the edges of the ventral beak, having been left in the absent matrix; and I take *k* to be the fractured edge of the dorsal beak surrounded by *k'*, that of the ventral beak.

The substance of the beak is black and carbonized, and exhibits no evidence of any calcareous coat. The irregularly dispersed hooks do not seem to have remained in place upon the bases of more than two of the arms. There are indications that they were disposed in double rows of opposite hooks along each arm.

The most perfect of these hooks (Plate I. [Plate 2], fig. 1a) measures about one-sixth of an inch in a straight line from its base to its apex. The basal part seems to be nearly square, and is hollow; from the base the hook is continued at first in nearly a straight line, and then bends sharply round to its acute point. The cavity of the base is traceable through the hook, and probably terminates by an aperture at, or close to, its point.

The ink-bag is not very clearly distinguishable (a dark spot at *m* only indicating its place) in this specimen; the great value of which consists in the demonstration which it affords of the co-existence of horny hooks and beak, a nacreous pro-ostracum, and the ordinary guard and phragmocone of a Belemnite; and, incidentally, of the justice of Dr. Buckland's identification of the Lyme Regis "*Belemnosepiæ*" with *Belemnites*.

So much difficulty attends the identification of the species of the *Belemnites*, that I hesitate to attach any specific name to this specimen. In many respects it is closely allied to the *Belemnites elongatus* of Sowerby; but the *Belemnites Bruguierianus* of D'Orbigny is abundant in the bed in which it was found, and my colleague, Mr. Etheridge, is of opinion that it belongs to that species, "though it has strong affinities with *B. Foumelianus* (D'Orb.)."

In the collections of Liassic fossils to which I have referred, and chiefly in that of Mr. Day, there is a series of fragmentary Belemnitic remains, consisting for the most part of ink-bags, associated sometimes

with more or less of the pro-ostracum, sometimes with hooks and imperfect beaks in very nearly natural relative positions; sometimes with more or less of the phragmocone, but hardly ever with a guard. That these belong either to the species already described, or to a closely allied one, is highly probable; in any case, the study of the features presented by some of them may help to throw light on the structure of the *Belemnitidæ* generally.

1. In a great many Belemnites I have observed conothecal striæ having the arrangement described by Voltz (Plate I. [Plate 2], figs. 6 and 7); but a large phragmocone from the *Ammonites obtusus* zone in the Rev. Mr. Montefiore's collection, the apex of which is broken off, but which still has a width of 2½ in. and a length of five inches, exhibits a disposition of the conothecal lines different from any which I have met with, or seen described. (Plate I. [Plate 2], fig. 4a.)

Only a small portion of the conotheca is preserved in this specimen, coating the cast of a phragmocone in calcareous spar, which exhibits the remains of the siphuncle very distinctly along the middle line of that face of the specimen which is turned to the right in the figure. This is, therefore, the ventral line, and the face turned to the eye is the left lateral face of the phragmocone, the figures not having been reversed. Now it will be observed that instead of one *asymptote* as usual, there are two, separated by an interval equal to about ¼th of the circumference of the phragmocone. Sharply arched hyperbolic lines, the ends of which pass into the asymptotes, and which are convex upwards, occupy the space between the two asymptotes; of which the one may be termed the *dorso-lateral*, the other the *ventro-lateral* asymptote.

Faint curved lines run obliquely upwards from the dorso-lateral asymptote towards the middle line of the dorsal region, so that the dorsal area of the conotheca doubtless had its usual set of upwardly convex curved lines. The ventral area, on the other hand, enclosed between the ventro-lateral asymptotes, exhibits no very distinct markings, though faint indications of transverse lines are discernible.

The conotheca in this case, therefore, differs from the ordinary type in having three sets, one medio-dorsal and two lateral, of upwardly convex curved striæ, and in possessing four asymptotes instead of two.

According to D'Orbigny ("Paléontologie Française," Terrains Jurassiques, Atlas, Plate 16, fig. 1), the conothecal lines of *Belemnites Puzosianus* have the ordinary arrangement, and the lateral bands of the pro-ostracum of this species would seem to correspond with the asymptotes.

If the arrangement of the conothecal lines, then, indicates the form of the pro-ostracum and *vice versâ*, the majority of Belemnites ought to have a two-banded pro-ostracum like that of *B. Puzosianus*; and, on the other hand, the peculiar arrangement of the conothecal lines of the present phragmocone ought to indicate that it was associated with a different kind of pro-ostracum; and, so far, there may be ground for suspecting that it belonged to some of the species which have pro-ostraca like that of *Belemnites Bruguierianus*.

But I am by no means satisfied of the justice of Voltz's assumption, which D'Orbigny and others adopt, that the conothecal lines must indicate the form of the pro-ostracum, since the latter may readily have been modified by the deposition of shelly matter upon its exterior, after its first formation.

2. The guard of the typical specimen of *Belemnites elongatus*, now in the British Museum, is covered by a superficial, smooth, thin, whitish, cuticular pellicle; and a better developed cuticle of the same kind has been brought under my notice by Mr. Day in specimens from the Upper Lias. A small example of the guard of apparently the same species (Plate I. [Plate 2], figs. 3, 3a, 3b), pointed out to me by Mr. Day, exhibits a much more developed cuticle. This is thrown into fine longitudinal wrinkles in its upper part, but, inferiorly, the wrinkles pass into minute ridges and tubercles. Both these and the wrinkles are larger, and extend farther up, on the dorsal than on the ventral, aspect of the guard.

Is the existence of this cuticular pellicle an indication of the completion of the growth of the Belemnite?

3. A splendid specimen in the collection of Mr. Norris (Plate II. [Plate 3], figs. 1, and 1a) shows very clearly the association of a phragmocone with a nacreous pro-ostracum and a large ink-bag. On the one face (fig. 1) this fossil exhibits the dorsal part of the pro-ostracum and its continuation into the guard, while, on the other face (fig. 1a) the huge ink-bag is displayed. The saddle-shaped, highly iridescent, region of the dorsal part of the pro-ostracum (*a*) terminates in well defined margins, both laterally and in front, the portion of the pro-ostracum with which it was continuous, at the sides, having broken away from this central region. On the left side, however, the lamellar continuation of the pro-ostracum towards the ventral surface (*b*) is well shown; and, like the dorsal portion, it is highly iridescent. When subjected to an oblique light, the pro-ostracum exhibits a shallow medio-dorsal longitudinal groove and indistinct lines of growth, which are convex upwards. The surface which continues the direction of the iridescent part of the pro-ostracum

upwards (*c*) has a granular pitted surface; but I am doubtful whether this appearance is due to the structure of the pen in this region, or to the manner in which fossilization has taken place.

The ink-bag is flask-like, 8 inches long, and 1¾ inches wide at widest.

4. In Mr. Day's collection, there is a specimen (No. 9) from the *Ammonites obtusus* zone, consisting of the upper part of the phragmocone, with almost the whole of the pro-ostracum, and the remains of many hooks in place.

A length of about 2¾ inches of the phragmocone is preserved; its upper end is 2½ inches wide, its lower end somewhat more than 1 inch, but both ends are greatly crushed. Nacreous shelly substance coats the exterior of the upper part of the phragmocone, and extends upwards over more than the lower half of the pro-ostracum, which has an oval form, and is nearly 10 inches long by 3½ inches wide.

The upper four or five inches of the middle portion of the pro-ostracum is formed of a thin plate of shelly matter, which is not iridescent, and beneath which there is no iridescent nacre. In the lower part of the pen the external non-iridescent substance has a subjacent, beautifully iridescent layer. In this, as in other cases, the nacre is bounded by a well-defined upper contour, which in this instance is convex.

The hooks of one arm have remained in position, and are arranged in two rows, and opposite to one another. One hook is so imbedded in the matrix as to expose its outer or convex side. In this, as in the lateral position, the base is much wider than the shaft of the hook.

The guard is not preserved in any of the preceding fragmentary specimens, while the ink-bag is but indistinctly traceable in the entire one first described. But any hypercritical doubt that might remain as to the possession of an ink-bag by a true Belemnite, must be removed by Mr. Day's specimen of *Belemnites elongatus* represented of one-half the natural size in Plate I. [Plate 2], fig. 2, which exhibits the guard and phragmocone complete, with a large and full ink-bag *in situ*. The ink-bag is pear-shaped, and tapers off to its duct. The length from the extremity of this to the base of the bag is 1·4 inch, the widest part of the bag measuring 0·55 of an inch. The shell from the apex to the mouth of the phragmocone is 5·35 inches long. The guard from its apex to the point at which it begins to expand over the phragmocone measures about 2¼ inches, and is 0·25 of an inch wide at widest.

These measurements may enable one to form a rough estimate

of the size of guard which appertained to any detached ink-bag, and *vice versâ*.

I have not been able to make out more than six or seven arms in any specimen, nor has any exhibited traces of elongated tentacula, though the shortness of the arms which have been preserved would lead one to suspect their existence. The hooks in the middle of the length of each arm seem to have been largest; those at the ends of the series, especially at the base, smallest.

The foregoing descriptions demonstrate that certain true Belemnites were provided with hooks upon their arms; horny beaks; large ink-bags; and with a pro-ostracum (into which iridescent, nacreous, shelly matter entered more or less largely) prolonged as a broad spatulate plate along the whole length of the dorsal region of the mantle, and produced laterally and inferiorly, for an unknown distance, along the lateral and ventral regions of the body.

But it by no means follows that all *Belemnitidæ* were provided with a pro-ostracum of similar form and character. On the contrary, it appears to me to be certain that there were at least two other kinds of pro-ostracum in this family.

Thus the Oxford Clay Belemnite, described by Mantell (Phil. Trans., 1848), under the name of *attenuatus*, a name which appears, like *B. Owenii*, to be only a synonym of *B. Puzosianus* (D'Orbigny) has a pro-ostracum which was very thin and apparently horny, or imperfectly calcified, in the dorsal region, and was supported laterally by two thin calcareous bands, or pillars, which, inferiorly, expand upon the conotheca.

A third very distinct type of pro-ostracum is exhibited by that remarkable Belemnitoid originally figured and described under the name of *Orthocera elongata*, by Sir Henry De la Beche,[1] who says in a note (l.c., p. 28), "I have ventured to class this specimen as an Orthocera, as it possesses more of the character of that genus than of the Belemnite, the external shell not exhibiting the radiating fracture of the latter, and I have given it a specific name from its great length in proportion to the diameter. Mr. White, to whom I am indebted for the specimen, informs me that it was originally considerably longer than at present."

As this specimen (now in the Museum of the Geological Society) is by no means well represented in the plate accompanying De la Beche's

[1] On the Lias of the coast in the vicinity of Lyme Regis, Dorset.—Transactions of the Geological Society, ser. 2nd, vol. ii. (1829), Pl. IV., fig. 4.

memoir, I have had a correct sketch of it made (Plate III. [Plate 4], fig. 3).

It consists of an imperfect sub-cylindrical guard 3·2 inches long; fractured above and below, and having, in its lower part, a diameter of rather less than one-fifth of an inch. It contains the remains of a long tapering phragmocone, the chambers of which have been completely filled with transparent calcareous spar. The rounded, bead-like apical chamber of the phragmocone, not one-fortieth of an inch in diameter, is situated at about 0·2 of an inch from the fractured extremity of the guard. The chambers gradually increase in length and in breadth, until at 2·25 inches from the apex they are 0·2 of an inch long by 0·25 wide. Beyond this point, the phragmocone is broken away, but the impressions of three chambers are left on the inner surface of the conotheca, which adheres to what remains of the attenuated, upward, prolongation of the guard. Altogether, there seem to have been about 30 chambers in the 2·9 inches length of phragmocone, but the 10 outermost chambers take up 1·8 inches of this extent. The conotheca is a thin lamella of a much paler colour than the guard, to the walls of the alveolus of which it adheres.

The real nature of this "*Orthoceras*" was first revealed by the beautiful specimen obtained by Mr. Day, which is represented in Plate III. [Plate 4], fig. 1, reduced to three-fifths of the natural size. Here, the apex of a phragmocone of similar character is inclosed within a sub-cylindrical guard, obtusely truncated at its free end. For an inch and a half from its distal end, this guard is entire, but beyond this point (*b*) it is split, and the dorsal has come away from the ventral half, leaving the phragmocone (*c*) exposed. The chambers of the phragmocone are filled with transparent spar, and their casts, thus produced, are exposed to view inferiorly. Superiorly, they are coated over by a thin pellicle of quite a similar character to the theca of the phragmocone in the original specimen; and, indeed, at the sides, this layer dips down between the fractured edge of the guard and the phragmocone, showing clearly that it is the conotheca.

At 3·6 in. from the end, the specimen is transversely fractured, and the section of the guard cannot be traced further than the fracture; but a layer of shelly matter (*a*) quite similar to that which forms the conotheca, and which was obviously continuous with it, coats what appears to be the upper termination of the phragmocone, and passes into the remarkable pro-ostracum, the extreme point of which is broken off: when it was entire it measured about 11¾ inches. Posteriorly it is a flat band 0·35 in. wide, which slowly narrows until its width is about 0·2 in.; it then widens to 0·5 in., and, finally,

gradually tapers to its point. Where it widens it thickens, and its surface, from being flat, becomes convex from side to side, so that its section acquires the form of a not very depressed ellipse, and this form is retained close to the apex at *f*.

The surface of this singular pro-ostracum is polished, but is covered with transverse wrinkles, or ridges, which are especially numerous where the flat portion passes into the rounded part.

The sections of the pro-ostracum exhibit its structure. Like the guard of an ordinary Belemnite, it is composed of concentric lamellæ, each of which consists of fibres disposed perpendicularly to the plane of the lamella, whence the cut surface presents concentric and radiating structure lines.

What the proper structure of the guard may be is more doubtful. In all specimens I have examined the texture of the guard is dense and thoroughly calcified, and any indications of structure are of a crystalline and not an organic character. The guard of the specimen longitudinally and vertically bisected, of which a diagram, one and a half times the natural size, is given in Plate III. [Plate 4], fig. 3, presents a dark longitudinal axial line, a dark terminal transverse line, and another less dark transverse line rather above the middle of its length.

The terminal transverse dark line is visible on the exterior of the specimen, and looks at first like a colour band, a sort of indication of the natural termination of the guard. But, on closer examination, these transverse markings are seen to arise merely from the presence of plates of calcareous spar; in other words, the calcareous infiltration is transparent in these parts of the fossil. The dark axial line appears to me to result from similar conditions.

The internal shell just described has not yet been found associated with ink-bag, hooks, or beaks. The peculiar form of the pro-ostracum, the long narrow phragmocone, and the cylindroidal guard, distinguish it generically from all the other *Belemnitidæ*. I, therefore, propose for this new generic type the name of *Xiphoteuthis*, and retain for the present, the only known species of the genus, De la Beche's term of *elongata*.

Is the guard entire in these specimens of *Xiphoteuthis elongata*, or has its apex been broken off? Was it originally solid and composed of fibrous lamellæ, or was it, like *Belemnites tubularis*, hollow through a greater or less part of its extent? The specimens which have passed through my hands do not enable me to give a definite reply to these questions.

I suspect that a thoroughly well-preserved specimen of *Belemno-*

teuthis will some day demonstrate the existence of a fourth kind of pro-ostracum among the Belemnitidæ. Mr. Pearce, as we have already seen, speaks of a "sepiostaire" in this genus; and Mr. Woodward ascribes to it "a horny dorsal pen, with obscure lateral bands." A specimen of *Belemnoteuthis* from the Oxford Clay, in the British Museum (Plate II. [Plate 3], fig. 2), shows very distinct traces of a pro-ostracum of this kind. The fossil is unfortunately much crushed, but from one lip of the phragmocone there obviously proceeds the horny-looking plate (*a*, *a*,) the two lateral contours of which, obscurely defined from the matrix, pass into one another at an acute angle at *b*. A narrow band of horny-looking matter, marked by oblique striæ, is discernible at *c*, and is quite distinct from the remains of the mantle (*f*), under which it seems to pass.

Is the triangular plate part of the ventral pro-ostracum, and the band *c* the remains of the dorsal portion of that structure? I am inclined to think so, though the state of the fossil is not such as to encourage positive assertion.

It has been seen that at least two genera of *Belemnitidæ*, viz., *Belemnites* and *Belemnoteuthis*, have hooks, arranged in double rows, upon their arms. Now similar hooks, sometimes isolated, sometimes associated with more or less complete remains of the animal to which they belonged, have been discovered in abundance in the Solenhofen slates, and have been referred by Wagner and Münster to the genus *Acanthoteuthis*. The interesting question therefore arises, was there, in the Mesozoic epoch, a cephalopod (*Acanthoteuthis*) with hooked arms, distinct from *Belemnoteuthis* and *Belemnites*; or are the Solenhofen fossils in question to be referred to one or other of these genera?

Count Münster's two memoirs on *Acanthoteuthis* are to be found in his "Beiträge zur Petrefacten Kunde" (Erstes und Siebentes Heft. Zweite Auflage).

In the first memoir, the genus is founded upon specimens of four species, consisting either of hooks alone, or of remains of the body and arms, the latter retaining their hooks.

In specimens of *Acanthoteuthis speciosa*, the first species, the mantle is said to be preserved, and in it "the broad sword-like pen, devoid of any distinct ridges, is visible" (l. c., p. 105); and, in both of these, "hooks are to be seen near the upper or cephalic end, perfectly similar to those figured in Plate IX." The hooks, situated in double rows along the arms, are marked by two ridges, one of which runs near the convex, and the other near the concave, side.

The second species is *Acanthoteuthis Ferussacii* (*A. prisca* of D'Orbigny), the only specimen of which exhibits an elongated mantle with a largish head, and short arms, provided with a double row of hooks. Each hook has only one ridge, situated towards the concave side.

The third species, *A. Lichtensteinii*, has short round hooks without ridges, and the fourth, unnamed, has hooks with two fine grooves on each side. But Count Münster communicated an important observation, bearing upon the present question, in a letter to Professor Bronn, published in Leonhard and Bronn's Jahrbuch for 1836 (p. 583):—

"From Solenhofen I have the large Phragmacone (Alveolkegel) of a Belemnite, with the unchambered hollow continuation of the shell, beside which lies the injured body (Sack) of a very large *Onychoteuthis*; round about are seen a few minute hooks from the arms of the Cephalopod. The two fossils lie so close together, and partly in super-position, that one might, at first, be led to believe them to belong to one and the same animal; but more careful examination shows that they proceed from two different animals, *Belemnites semisulcatus* and *Onychoteuthis speciosa* (the largest fossil kind with which I am acquainted). Notwithstanding all the trouble which I have taken to find a *Belemnosepia* of Buckland in the slates of the Lias and of Solenhofen, I have as yet met with no success; in no German collection with which I am acquainted is there any true *Belemnosepia*, for which, at first, I took the fossil just described."

Professor A. Wagner ("Die fossilen Ueberreste von nackten Dintenfischen," 1860), however, having had the opportunity of carefully examining all Münster's specimens, and of collating them with others, leads us to believe that the earlier opinion was more correct than the later. He says (p. 820), that he was at first of the same opinion as Count Münster, but that he is now perfectly persuaded, "that on the slab in question there are not two examples of different genera, but only a single individual specimen. The phragmocone is, in fact, directly connected with the posterior margin of the mantle, and exhibits the same structure as that of *Acanthoteuthis* (*Belemnoteuthis*) *antiqua*, although only a coarse impression of it is left. The whole length of this individual, from the base of the arms to the apex of the phragmocone, is above 14 inches."

At a previous page (777) Wagner states that a few hooks lie beside the head of this specimen, and that the form of its body is exactly like that of *A. Ferussacii*. "But what gives this specimen its greatest value is the circumstance that, in the posterior part of the mantle-sac, at its posterior as well as at its two lateral edges, a few delicate fragments of a brown, horny, irregularly fissured pen (Schulpe) are visible."

In the second essay ("Ueber die Schalenlosen Cephalopoden des

oberen Juragebirgs), Münster says he is not certain what kind of mantle or pen might have belonged to *Acanthoteuthis speciosa*, nor has he any knowledge of the pen of *A. Ferussacii*, or of *A. Lichtensteinii*; but he proceeds to describe some new species, prefacing his account of them with some general remarks, as follows:—

"The bodies of all the species known to me have a narrow elongated form, which sometimes is elliptical, sometimes ovate, sometimes fusiform, or even conical. Since, in a few specimens, impressions of hooklets are discoverable at the upper part of the body, which agree perfectly with the three foregoing, and besides, coprolites not uncommonly occur in the slates, which consist exclusively of the remains and undigested parts of these naked cephalopods, namely, of the middle keel of the pen, which is crushed into many short pieces, and of the hooklets of the arms, which, sometimes large and sometimes small, lie scattered round the fragments of the pen in great numbers; I have not hesitated to ascribe all these bodies and pens to the genus *Acanthoteuthis*, until this view is upset by complete specimens," p. 57.

Thus '*Acanthoteuthis*' *speciosa* turns out to be one of the *Belemnitidæ*, but the statements before us leave it doubtful whether it was like *Belemnoteuthis*, devoid of an elongated guard, or whether it is really a *Belemnites semisulcatus* with the guard broken off.

With respect to "*Acanthoteuthis*" *Ferussacii*, of which only one specimen exists, Wagner is uncertain as to its distinction from the former species, and believes it to be identical with *A. Lichtensteinii*; and at any rate, as the head and trunk have left only an impression, and not a trace of any internal parts is to be seen (Wagner, l.c., p. 775), there is no evidence to show that it, also, may not be a *Belemnites*, or a *Belemnoteuthis*.

Of the other *Acanthoteuthes* enumerated in the second memoir, Count Münster does not profess to have found hooks associated with *A. Angusta*, *A. lata*, *A. subovata*, *A. subconica*, *A. acuta*, *A. brevis*, *A. intermedia*, *A. rhomboidalis*, *A. semistriata*, and *A. tricarinata*, all of which are referred to a different genus, *Plesioteuthis*, by Wagner; while Wagner, after examination of the same specimens, denies the existence of hooks in *A. Orbignyana* and others, to which Münster ascribed them.

Thus, the existence of *Acanthoteuthis* as a genus apart from *Belemnites*, or *Belemnoteuthis*, becomes exceedingly doubtful. But it does not follow from this that no other Mesozoic *Cephalopoda* were provided with hooked arms, and indeed there is evidence that at least two genera, *Plesioteuthis* (Wagner) and *Celæno* (Münster) were. In the first place Count Münster affirms, and Professor Wagner agrees with

him, that coprolites are not unfrequently found in the Solenhofen slates, "which consist exclusively of the remains of undigested parts of naked cephalopods, namely, of the middle keel of the pen, which is crushed into many short pieces, and of the hooklets of the arms, which, sometimes large and sometimes small, lie scattered round the fragments of the pen, in great numbers." Wagner adds to this (l.c., p. 785) that the fragments of the pen are part of the keel and of the lateral wings of pens, appertaining, almost wholly, to animals in which the latter are sword-shaped and thin, and for which Wagner proposes the generic name *Plesioteuthis*. It would therefore appear that *Plesioteuthis* had hooks, though Wagner's statement that he had never, either in Münster's collection, or any other, found hooks associated with these sword-shaped pens,[1] is, so far as negative evidence goes, somewhat against that conclusion.

In the next place, Professor Wagner (l.c., p. 783) describes an impression of *Celæno conica* displaying hooks similar to those of "*Acanthoteuthis Ferussacii*" and in addition, the remains of acetabula.[2]

Upon the whole it becomes plain that the *Acanthoteuthes* of Münster, so far as they are known only by hooks and impressions of soft parts, may have been either *Belemnites* or *Belemnoteuthes*, or *Plesioteuthes*, or may have belonged to the genus *Celæno*; and that, with the evidence before us, it is impossible to say whether *Acanthoteuthis speciosa* and *Ferussacii* belong to *Belemnites*, or to *Belemnoteuthis*.

Under these circumstances, it appears to me that there is no good ground for abandoning the name *Belemnoteuthis*, applied by Pearce to one of the best known and most clearly definable of fossil *Cephalopoda*, for *Acanthoteuthis*. Though it is quite possible that either *A. speciosa* or *A. Ferussacii* may be really a *Belemnoteuthis*, we have no certain knowledge of the fact; and even if such be the case, it would be better to separate these forms as *Belemnoteuthis*, and to retain *Acanthoteuthis* for the *Plesioteuthis* of Wagner.

The genera hitherto enumerated in the family of the *Belemnitidæ*, characterized among the Dibranchiate *Cephalopoda* by possessing a straight, chambered, siphunculated, internal shell, or phragmocone, are *Belemnites*, *Belemnitella*,[3] *Belemnoteuthis*, *Beloptera*, and *Conoteuthis*.

[1] Out of coprolites, that is to say.

[2] Wagner speaks of these as "hitherto never observed in fossil Cephalopoda" (p. 783), but he has overlooked a paper "On the fossil Cephalopoda constituting the genus Belemnoteuthis," by Mr. J. C. Pearce, F.G.S., published in the "London Geological Journal," No. II., February 1847, in which the acetabula of *Belemnoteuthis* are described and figured. (Pl. XVI.)

[3] See, however, with respect to *Belemnitella* and *Actinocamax*, the important observations of Saemann, "Observations sur Belemnites quadratus, Defr."—Bull. de la Société

To these *Xiphoteuthis* must now be added, and I think it very proba that by-and-by it will be found necessary to subdivide *Belemnites*, difference between the pro-ostraca of *B. Bruguierianus* and *Puzosianus* being, probably, of generic importance.

The extent of our knowledge of the structure of these diffe genera is very unequal. Of *Belemnoteuthis*, the body and arms, ho ink-bag, and internal shell are all known, few fossilized animals hav left more complete remains; of *Belemnites*, the specimens describe this paper have made known, for the first time, the form and proj tions of the body and the arms, the hooks, the ink-bag, one typ pro-ostracum; and, less perfectly, the beak; of *Xiphoteuthis*, almost complete internal shell is known; of *Conoteuthis*, the phrag cone and part of the pro-ostracum; of *Beloptera* and *Belemnitella*, c the phragmocone and guard; but with the hooks, ink-bag, or parts of these last four genera we have no acquaintance.

DESCRIPTION OF THE PLATES.

⁂ *None of the Drawings have been reversed.*

PLATE I. [Plate 2].

Fig. 1. *Belemnites Bruguierianus.* The property of the Rev. Mr. Montefiore.

Fig. 1*a*. Hooks of the arms magnified.

Fig. 2. *Belemnites elongatus*, with the ink bag. In the collection of the Britisn Mus

Fig. 2*a*. Hooks magnified.

Fig. 3. A guard of *B. elongatus*, with a wrinkled cuticle. In Mr. Day's collection.

Fig. 4. Part of a Belemnitic Phragmocone, with dorso-lateral and ventro-lateral as totes. In the collection of the Rev. Mr. Montefiore.

Fig. 4*a*. The entire Phragmocone, three-eighths the natural size.

Fig. 5. The remains of the arms of a Belemnite, not associated with any other part animal, showing the arrangement of the hooks. From a specimen in Mr. Day's collecti

Fig. 5*a*. Some of the hooks magnified.

Figs. 6 and 7 are copied from Voltz (Plate VII. fig. 2. *B. paxillosus*), to show the ord disposition of the conothecal lines of Belemnites.

PLATE II. [Plate 3].

Figs. 1 and 1*a*. Dorsal and ventral view of the associated phragmocone, pro-ostra and ink bag of a Belemnite in Mr. Norris' collection.

Fig. 2. *Belemnoteuthis antiquus.* In the collection of the British Museum.

PLATE III. [Plate 4].

Fig. 1. *Xiphoteuthis elongata*; dorsal view of a nearly entire specimen, reduced to fifths the natural size.

Fig. 1*a*. Lateral view of the same.

Fig. 2. The original *Orthocera elongata* of De la Beche.

Fig. 3. Polished section of the guard and phragmocone of *Xiphoteuthis elongata*, on a half times the natural size.

Fig. 4. A very perfect specimen of the pro-ostracum of *Xiphoteuthis elongata*, quarters of the natural size.

⁂ *All these specimens are in Mr. Day's collection.*

Géologique de France, 1862. M. Saemann brings forward evidence to show that apparently distinct generic types arise merely from the defective calcification of the part of the rostrum of a Belemnite.

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III

ON THE OSTEOLOGY OF THE GENUS GLYPTODON.

Philosophical Transactions of the Royal Society of London, 1865, *vol. clv.*, *pp.* 31—70. (*Received December* 30, 1863. *Read January* 28, 1864.)

Part I.—The history of the discovery and determination of the remains of the *Hoplophoridæ*.

Part II.—A description of the skeleton of *Glyptodon clavipes*, Owen (*Hoplophorus Selloi*, Lund ?).

§ 1. Description of the Skull.

§ 2. Description of the Vertebral Column.

PART I.—*The history of the discovery and determination of the remains of the* Hoplophoridæ, *or animals allied to, or identical with,* Glyptodon clavipes.

THE earliest notice of the discovery of the remains of *Glyptodon*-like animals is contained in the following extract from a letter, addressed to M. Auguste St. Hilaire by Don Damasio Larañaga, Curé of Monte Video, which appears in a note at p. 191 of the fifth volume of the first edition of Cuvier's 'Ossemens Fossiles,' published in 1823:—

"I do not write to you about my *Dasypus* (*Megatherium*, Cuv.), because I propose to make it the subject of a memoir which, I trust, may not be unworthy of the attention of those European savants who take an interest in fossils. I will merely say that I have obtained a femur, which was found in the Rio del Sauce, a branch of the Saulis Grande. It weighs about seven pounds, and may be six or eight inches wide. In all points it resembles the femur of an Armadillo. I will send you one of its scales. The tail, as you have seen, is very short and very large; it also possesses scutes, but they are not arranged in rings, or in whorls. These fossils are met with, almost at the surface, in alluvial, or diluvial, formations of a very recent date.

It would seem that similar remains exist in analogous strata near Lake Merrim, on the frontier of the Portuguese colonies."

Cuvier expresses no opinion as to the accuracy, or otherwise, of Don Damasio Larañaga's identification of his *Dasypus* with the *Megatherium*, an identification which, it will be seen, was erroneous.

The volume of the Transactions of the Royal Academy of Sciences of Berlin for the year 1827 contains a memoir by Professor Weiss [1] upon the collections of fossils and minerals gathered in South America by Sellow, accompanied by five plates, four of which display excellent representations of various portions of the dorsal and caudal dermal armour, and of part of a femur, of one or more species of *Glyptodon*. Some of these fossils (the fragments of the dorsal dermal armour) were obtained at three feet from the surface, in the marly clay of which the banks of the Arapey Chico (a branch of the Arapey Grande, an affluent of the Uruguay) are formed. The skeleton of the *Megatherium* now at Madrid was found in a similar clay which underlies Buenos Ayres. The femur and the fragment of caudal armour were procured from the banks of the Quegnay, a more northern affluent of the Uruguay than the Arapey.

Weiss remarks upon these fossils (*l. c.*, p. 276), "that it can hardly be doubted that they belonged to no other animal than the *Megatherium*, Cuv. Cuvier himself published, in a note to p. 191 of his 'Recherches sur les Ossemens Fossiles,' t. v. 1e partie, the first information which he received, in 1823, that his *Megatherium* was a loricated animal. M. Larañaga, parish priest of Monte Video [2] (from whom this information was derived, and in whose house M. Sellow, in 1822, saw two fragments of the armour, one belonging to the back and the other to the tail, which were found between Monte Video and Maldonado, in a gully opening into the Arroyo de Solis), believed the animal to be an Armadillo, *Dasypus*; Cuvier had already pointed out the similarity of the extremities to this genus and to *Myrmecophaga*. However, the armour plates found on the Arapey show no trace of a zonary arrangement, and the fragments possessed by M. Larañaga also leaving a doubt on this point, it may remain an open question

[1] Ueber das südliche Ende des Gebirgzuges von Brasilien in der Provinz San Pedro do Sul und der Banda Oriental oder dem Staate von Monte Video: nach den Sammlungen des Herrn Fr. Sellow, von Herrn Weiss (Gelesen in der Akademie der Wissenschaften am 9. August 1827, und 5. Juni 1828).

[2] ["A friend of natural history and, in every way, an estimable man, who has now unfortunately become blind," writes M. Sellow regarding him to M. von Olfers on the 10th October, 1829. We can therefore no longer look for the appearance of his promised essay on these fossil remains.]

whether the Megatherium possessed a veritably jointed armour, or whether it was not more probably provided with a solid shield."

The figures show, and Professor Weiss remarks upon, the raised conical form of the marginal pieces of the carapace.

In the course of his description of the parts of the skeleton of a Megatherium sent to this country by Sir Woodbine Parish, Mr. Clift[1] remarks, "In these latter instances the osseous remains were accompanied by an immense shell or case, portions of which were brought to this country; but most of the bones associated with the shell crumbled to pieces after exposure to the air, and the broken portions preserved have not been sufficiently made out to be, at present, satisfactorily described. Representations, however, of parts of the shell in question are given in the plate annexed."

The plate (46) to which reference is here made exhibits views of the inner and outer surfaces of parts of the carapace of a *Glyptodon.* In a note (p. 437) Mr. Clift mentions that casts of the principal bones in question have been sent, among other places, to the Jardin des Plantes at Paris.

The next work upon this subject in the order of time, is the very valuable essay communicated by Professor E. D'Alton to the Berlin Academy in 1833.[2] Sellow had been compelled by the local authorities to send to Rio Janeiro all the bones and the finest pieces of the carapace, which he discovered in association with the fragments of dermal armour figured by Weiss[3]; but, by good

[1] "Some account of the Remains of the Megatherium sent to England from Buenos Ayres by Woodbine Parish, jun., Esq., F.G.S., F.R.S." By William Clift, Esq., F.G.S., F.R.S. Read June 13, 1832. Transactions of the Geological Society, vol. iii. 2nd series.

[2] "Ueber die von dem verstorbenen Herrn Sellow aus der Banda Oriental mitgebrachten fossilen Panzer-Fragmente und die dazu gehörigen Knochen-Ueberreste," with four plates. The volume of the 'Abhandlungen der Königlichen Akademie der Wissenschaften,' in which this essay appears, was published in 1835.

[3] Professor Owen writes (On the *Glyptodon clavipes*, Geol. Trans. vol. iii. pp. 82, 83), "The portions of the tesselated bony armour figured by Professor Weiss, pl. 1 and 2, and described at p. 277 of his memoir, were obtained by Sellow on the Arapey-Chico in the province of Monte Video; but no bones either of the Megatherium, or any other animal, are mentioned as having been associated with them. A third series of fossils, in which fortunately some bones of the extremities were discovered associated with the tesselated bony case, was presented to Sellow by the President of the province of San Pedro, with the information that they had been originally discovered in the proximity of Rio Janeiro."

This, however, appears to be a misapprehension of the state of the case. The armour figured by Weiss in pl. 1 and 2 of his memoir, and the "third series of fossils" were associated together; and so far from the President of the province of San Pedro having presented anything to Sellow, it was Sellow who was obliged to present the fossils to the President, or at any rate, to dispose of them according to his orders. "Denn die Aufforderung des

fortune, these additional materials at length found their way into the Berlin Museum, and afforded D'Alton the materials for his memoir, in the first section of which the pieces of the carapace of the fossil animal are described ; while the second section is devoted to an account of the structure of the dermal armour of living Armadillos, and the third to a description of the fossil bones found in juxtaposition with that dermal armour.

The results of the comparison of the fossil armour with that of existing Armadillos are thus stated:—

"If we compare these fossil dermal plates with those of living species of *Dasypus*, it becomes obvious that all the peculiarities of the former may be paralleled by the latter; but with this difference, that while, as appears from Sellow's report, all the fossil plates belonged to one and the same animal, their peculiarities are not all found associated together in any one living species. The majority of the fossil plates which were distant from the margin, *e.g.* those represented by Weiss in figs. 1, 4, and 5, and many described above, exhibit the greatest similarity to the dermal plates of *Dasypus niger* ; and thence it may be concluded that the epidermis of the *Dasypus* of the ancient world (if for brevity's sake I may so name the animal), like that of the *Dasypus niger*, was divided differently from the bony plates, and that strong hairs were arranged in the interstices of the epidermic scales.

"The pieces which belonged to the edge, or the pointed marginal scutes (Zacken), most nearly resemble those of *D. Poyou* (fig. 12 of our first Plate), and *D. grandis* shows a somewhat similar formation. In addition, the thoracic shield and the moveable zones of *D. villosus* (fig. 18) are also provided with pointed marginal scutes; and, according to Azara, the *Tatou pichey* exhibits similar structures. But in all the animals provided with such pointed scutes, they are directed from above, and forwards, downwards, and backwards; and therefore some of the fragments may be referred to the left, and some to the right side. . . . From the preceding comparisons it follows that the fossil scutes are similar to those of the thoracic and pelvic shields of different living Armadillos, although they differ from them in many respects. But if objections should still be raised to regarding the animal which bore the fossil armour as an Armadillo (Gürtelthier), two replies may be made. In the first place, neither the entire skeleton nor the perfect shell of the animal have been obtained. Of

damaligen Präsidenten der Provinz San Pedro, des Visconde des S. Leopoldo, nöthigte ihn [Sellow] den hauptsächlichsten Theil dieser fossilen Ueberreste nach Rio Janeiro abzuliefern."

It is therefore sufficiently obvious that the fossils were not found *at* Rio Janeiro, but were sent *to* that place from Arapey-Chico.

the skeleton, the vertebral column, the ribs, and sternum are wanting—or exactly those parts which the moveable zones (Gürtel) would have covered. Secondly, the moveable zones themselves, although among the characteristic features of the Armadillos, are of less importance than was formerly believed, as Azara has already pointed out."

The state of the bones indicated that they appertained to a young animal, the epiphyses being distinct. Those described belonging to the fore limb are, a part of the scapula (?), the distal end of the left humerus, the radius and ulna, nearly perfect, and eighteen bones of the fore foot. Of the latter, five belonged to the carpus, of which the three proximal are interpreted by D'Alton as the *semilunare* (Mondbein), *cuneiforme* (das dreieckige Bein), and *pisiforme* (Erbsenbein). I shall endeavour to show, in the course of my description of the specimen which forms the subject of this memoir, that the determinations of the *semilunare* and *cuneiforme* are perfectly correct, but that the so-called *pisiforme* is not rightly named. The distal bones are, according to D'Alton's interpretation, which I can fully confirm, the *magnum* and the *unciforme*.

Two entire metacarpal bones, and fragments of another, are considered by the author of the memoir to correspond with the third, fourth, and fifth of an ordinary five-toed fore foot; but they are really the second, third, and fourth, Professor D'Alton having taken the surface of the cuneiform, which articulates with the fifth metacarpal, for the surface of articulation with the pisiform. The phalanges of the digits belonging to these metacarpal bones, and three of their sesamoid bones, are carefully described and figured.

The resemblances of the bones of the forearm with those of the existing Armadillos are pointed out, especial weight being laid upon the extension of the cuneiform round the unciform, and its articulation with what D'Alton supposes to be the fifth metacarpal; and certain analogies of the fore foot with that of the mole are indicated.

A fragment of the distal end of a leg-bone, the seven tarsal bones, the four outer metatarsal bones; their digits, except the ungual phalanges; and some other bones of the hind foot, in a more or less fragmentary state, are described and figured, and attention is drawn to the remarkably short and strong character of the foot.

In conclusion D'Alton remarks, "Though, as I have endeavoured to show above, there is a certain agreement between the *manus* of the fossil animal and that of the Armadillos, yet the foot shows us no greater similarity than may be observed between it and many other five-toed animals. Hence the osteology of the primeval animal does

not afford a sufficient confirmation of the view which we derived from the consideration of the carapace, viz. that the bones, together with the fragments of dermal armour, might have belonged to an animal nearly allied to the Armadillos, or perhaps even to a very large, probably extinct, species of *Dasypus*. The fossil bones are too few to afford a safe foundation for so decided an opinion respecting the zoological affinities of the animal. A tolerably perfect skeleton is necessary in order to enable us, from the bones alone, to draw a safe conclusion as to the structure of the remainder of an animal."

Singularly enough, D'Alton does not mention the *Megatherium* throughout this paper, which however affords, by implication, an ample demonstration that the bony armour described has nothing to do with that animal.[1]

In 1836, Laurillard, in editing the eighth volume of the second edition of Cuvier's 'Ossemens Fossiles,' appends the following note to the letter of Don D. Larañaga, quoted above :—

"It is very possible that the *Megatherium* was, in fact, covered by a scaly cuirass ; but the great fragments which have been found must not be hastily attributed to it ; for the plaster casts sent from London[2] prove that an Armadillo of gigantic size coexists with the *Megatherium* on the plains of Buenos Ayres. These characteristic fragments consist of a calcaneum, an astragalus, and a scaphoid, which depart from those of existing Armadillos only in size, and by purely specific differences."

In 1836, then, it was clearly made out that the cuirassed extinct animal of South America is *not* the *Megatherium* and *is* allied to the Armadillos. However, Dr. Buckland, whose Bridgewater Treatise appeared in this year, and who therefore could hardly have been acquainted with the views of D'Alton and of Laurillard, still associated the dermal armour with the Megatherium—supporting his views by an elaborate and ingenious teleological argument, which, like most reasonings of the kind, appeared highly satisfactory. But, in 1837, all further doubt upon the subject was removed by the discoveries of Dr. Lund, who, in that year, despatched to Copenhagen the second of the remarkable series of memoirs in which he reconstructed the

[1] Thus Müller says in his memoir on the hind foot, cited below, "In der letzten Abhandlung ist von Herrn D'Alton bewiesen, dass der Panzer nicht dem *Megatherium* angehört."

[2] *Vide supra*, p. 38. Mr. Pentland appears to have been led to the same opinion by the examination of these casts in 1835. See Transactions of the Geological Society, vol. vi. ser. 2nd, p. 85, and Mr. Pentland's letter to M. Arago in the 'Comptes Rendus' for March 11, 1839.

ancient Fauna of Brazil.[1] In this paper Dr. Lund established the genus *Hoplophorus* upon the dermal armour and certain bones of an edentate quadruped closely allied to, if not identical with, the "Dasypus" of Larañaga.

Hoplophorus euphractus, the sole species of the new genus described in the memoir, was estimated by its discoverer to be of the size of an ox, and to have been provided with a carapace most nearly resembling that of *Tolypeutes*, but of an astonishing thickness. The extremities are said to have the general structure of those of the Armadillos, the feet being short and thick, with remarkably broad and short nails; so that they must have resembled those of an Elephant, or a Hippopotamus. The skull was sloth-like, and its jugal arch exhibited the structure characteristic of those animals. The teeth were similar to the molars of *Capybara*, but simple instead of being made up of many plates.

Professor Bronn, publishing the second edition of his 'Lethæa Geognostica' in the spring of 1838, and unacquainted with Lund's labours, proposed the name of *Chlamydotherium* for the animal to which the carapace described by Weiss and D'Alton belonged, in case the foot should really appertain to it; and *Orycterotherium*, in case the foot should belong to a different animal.

In March of the same year, it appears that M. Vilardebo, Director of the Museum of Monte Video, and M. Isabelle published conjointly, in Nos. 2551, 2553, and 2555 of a journal, the 'Universal,' an account of an animal which they had discovered on the Pedernal, in the Department of Canelones.[2]

After removing a thin layer of clay, these observers met with a shield formed of pieces of bone separated from one another by a slight interval; these pieces, 25 to 50 millimetres in diameter, and varying in thickness from 12 to 40 millimetres, were hexagonal: the largest occupied the dorsal region of the carapace, and the smallest its lateral regions. Each polygon presented a central disk (14 to 27 millimetres in diameter), from whence radiated six or eight lines, between which as many quadrangular areæ were left. These pieces of bone were symphysially united so as to form a very regular mosaic: the carapace appeared to be fringed with conical pieces forming a

[1] "Blik paa Brasiliens Dyreverden för sidste Jordomvæltning. Anden Afhandling. Patte dyrene. Lagoa Santa, 16de Novbr. 1837," published in 'Det Kongelige Danske Videnskabernes Selskabs Naturvidenskabelige og Mathematiske Afhandlingar,' Ottende Deel, 1841, p. 70. A notice of Lund's labours, containing the names of his genera, is to be found in the 'Oversigt over det Kongelige Danske Videnskabernes Selskabs Fordhandlingar i Aaret 1838,' published by Örsted, the Secretary of the Academy.

[2] See the Bulletin de la Société Géologique de France, t. xi. p. 159 (1840).

semicircle of 24 centimetres. The carapace was about 4 metres wide, and was as convex as a cask. The bones discovered in it were lumbar vertebræ and pelvic bones. In another place was discovered a femur about 0·57 metre long, with many plates of the carapace, and a tail formed of a single mass of bone (covered nevertheless by pieces soldered together), in the middle of which were widely separated caudal vertebræ. The tail was more than 0·50 metre long, and more than 0·36 metre in diameter at the base.

The authors discuss the question—to what class do these fossils belong?—with much sagacity, and conclude by expressing the opinion that they appertain to a species of *Dasypus*, which they term *D. antiquus*, and which they briefly characterize as follows: "*Cingulis dorsalibus nullis: verticillis caudalibus nullis.*"

The volume of the Transactions of the Danish Academy, already cited, contains another communication from Dr. Lund, dated Lagoa Santa, September 12, 1838, in which he speaks of the fossils described by D'Alton, and identifies the animal to which they belonged, generically, with *Hoplophorus*, though he regards it as a distinct species, and names it *Hoplophorus Selloi.* Accompanying this paper are sundry figures of parts of the carapace and of bones of the hind foot of *Hoplophorus.*

Dr. Lund returns to the subject in a long letter addressed to M. V. Audouin, dated the 5th of November 1838 (extracts from which are published in the 'Comptes Rendus' for the 15th of April 1839), which contains an enumeration, with brief descriptive notices, of the seventy-five species of fossil Mammalia which this untiring explorer had extracted in the preceding five years from the caverns of Brazil. Among the rest the writer describes:—

"6°. *Hoplophorus*, a genus very remarkable for the heavy proportions of its species, for their gigantic size, as well as for the singular manner in which it combines different types of organization; however, their characters approximate them most nearly to the Sloth family. These strange animals were armed with a cuirass which covered all the upper part of the body, and which was composed of little hexagonal scutes, except in the middle of the body, where the scutes took a quadrate form, and were disposed in innumerable transverse bands. The bones of the trunk, as well as the great bones of the extremities, are also very similar to those of the Tatous, and particularly to those of the Cachicames; but the bones which compose the feet are so shortened and have their articular faces so flattened, that nothing similar is to be seen in any animal skeleton, and that it is inconceivable how such feet should have been used in digging. The

form of the teeth also indicates that these singular animals could feed only on vegetable substances, and it is to be supposed that they grazed after the fashion of the great Pachyderms. However this may be, the *Hoplophorus*, of which M. Lund describes two species, present the peculiarity, hitherto regarded as special to the Sloth, of having a descending branch to the zygomatic arch. These two species were as large as an ox. Fragments of the skeletons have already been described by MM. Weiss and D'Alton of Berlin." — *Loc. cit.* pp. 572, 573.

A summary of Lund's researches, despatched by him from Lagoa Santa on November 5th, 1838, and published in the Annales des Sciences Naturelles for 1839, under the title of "Coup d'œil sur les espèces éteintes de mammifères de Bresil: extrait de quelques mémoires présentés à l'Académie Royale des Sciences de Copenhague," gives a substantially similar account of *Hoplophorus*. The species *Hoplophorus Selloi* is identified with the cuirassed animal described and figured by Weiss and D'Alton.

The sixth volume of the second series of the Transactions of the Geological Society contains an elaborate memoir by Professor Owen[1] on the bones associated with the dermal armour, figured by Mr. Clift in the memoir already cited; and on certain teeth, upon which the genus *Glyptodon* was founded by the same writer, in Sir Woodbine Parish's work on Buenos Ayres.[2]

Professor Owen considers these remains to be specifically identical with those collected by Sellow, and described by Weiss and D'Alton; so that if Lund was right in ascribing the same fossils to his genus *Hoplophorus*, *Glyptodon* becomes a synonym of the latter.

In the memoir under consideration the general form and the minute structure of the teeth, the distal end of the humerus, the radius, two phalanges of the fore foot, "the anchylosed distal extremities of the tibia and fibula, an astragalus, calcaneum, scaphoides, cuboides, external cuneiform bone, the three phalanges of the second toe, and the middle and distal phalanges of the third and fourth toes, with a few sesamoid bones," all belonging to the left side, are described; while the tooth and the bones of the leg and foot are figured.

1 "Descriptions of a tooth and part of the skeleton of the *Glyptodon clavipes*, a large quadruped of the edentate order, to which belongs the tesselated bony armour described and figured by Mr. Clift in the former volume of the Transactions of the Geological Society, with a consideration of the question whether the Megatherium possessed an analogous dermal armour." By Richard Owen, Esq., F.G.S., F.R.S. (Read March 23rd, 1839: an abstract of this paper appeared in No. 62 of the 'Proceedings.')

2 'Buenos Ayres and the provinces of the Rio de la Plata,' 1838, p. 178 *e*.

Professor Owen considers that the dental characters "seem to indicate a transition from the *Edentata* to the pachydermatous *Toxodon*," and sums up his general conclusions as to the affinities of *Glyptodon* thus:—

"It may be concluded, therefore, that the extinct edentate animal to which belongs the fossil tesselated armour described by Weiss, Buckland, and Clift, cannot be called an Armadillo, without making use of an exaggerated expression, and still less a species of *Megatherium*; but that it offers the type of a distinct genus, which was much more nearly allied to the Dasypodoid than to the Megatherioid families of Edentata, and most probably connected that order of quadrupeds with the heavy coated Rhinoceros of the Pachydermatous group" (*l. c.* p. 96).

In the same year (1839) Professor D'Alton proposed for the animal, the remains of which he had originally described, the name of *Pachypus*; so that by this time no fewer than six names had been applied to mammals all of which are certainly closely allied to the *Hoplophorus* of Lund, whether they are, or are not, generically identical with it, and which may therefore be appropriately termed *Hoplophoridæ*.

In 1845 Professor Owen returned to the Glyptodon question, in the 'Descriptive and illustrated Catalogue of the Fossil Organic Remains of Mammalia, and Aves contained in the Museum of the Royal College of Surgeons of England.'

It is here stated (p. 107) that "those specimens of the present genus which were presented to the College by Sir Woodbine Parish are from a low marshy place, about five feet below the surface, in the bank of a rivulet, near the Rio Matanza, in the Partido of Canuelas, about twenty miles to the south of the city of Buenos Ayres." The parts thus found associated are not stated, with the exception of the bones of the left hind leg and foot (p. 111), to have belonged to the same individual. They consist of a molar tooth, part of the left ramus of the lower jaw, a fragment of the humerus, the left radius, a metacarpal bone and two phalanges, the shaft and distal epiphyses of the femur (?), the anchylosed distal ends of the tibia and fibula, and numerous bones of the left hind foot. These had already been described and figured in the Geological Society's Transactions.

As new specimens, there are described and figured an almost entire carapace of *Glyptodon clavipes*, from the Pampas of Buenos Ayres, and many dermal bones, all of which are marked "Purchased," and appear not to have been accompanied by bones of the endoskeleton. Nos. 551, 552, 554, 555, 556, 557 are fragments of carapace,

all presented by Sir Woodbine Parish, and obtained from the locality mentioned above. They are ascribed by Professor Owen to no less than three distinct species, however, viz., *Glyptodon clavipes*, *G. reticulatus*, and *G. ornatus*; a fourth species, *G. tuberculatus*, is based upon purchased specimens, from the Pampas of Buenos Ayres, the precise locality of which is not stated.

The fact that the dermal ossicles of three species of *Glyptodon* were found in the same locality as the bones described, and the absence of any evidence demonstrating the association of the ossicles ascribed to *G. clavipes*, rather than those attributed to the other species, with the bones, throws, it will be observed, some doubt upon the certainty of that ascription, and opens the question whether the bones really belonged to one form of carapace or to another.

Of the Plates which illustrate the 'Catalogue,' the first contains a side view, partly restored, of the *Glyptodon clavipes*; the second, views of the carapace and tail; the third, of the skull; the fourth and fifth, of parts of the carapace; and the description of the Plates comprises accounts of the structure of the skull and of the tail, parts which had not been received until after the printing of the body of the catalogue.

In what locality the skull and the tail were obtained, and upon what evidence they are ascribed to the particular species, *G. clavipes*, is not stated. The lower jaw and the defensive bony covering of the skull in Plate I "are restored on the authority of an original sketch of an entire specimen of this species of *Glyptodon* transmitted to Sir Woodbine Parish from Buenos Ayres." The bones of the fore foot are given in outline after D'Alton.

On the 8th of June, 1846, the late Johannes Müller read a short paper to the Berlin Academy upon the bones of the leg and hind foot described by D'Alton, which had been worked out and mounted by the help of Professor Owen's memoir. This paper, accompanied by an excellent plate, was published in 1849.[1]

The number of the 'Comptes Rendus' for August 28, 1855, contains a "Description d'un nouveau genre d'Edenté fossile renfermant plusieurs espèces voisines des Glyptodons, et classification méthodique de treize espèces appartenant à ces deux genres," by M. L. Nodot, Director of the Museum of Natural History at Dijon; and this essay, enlarged and illustrated with plates, appeared two years later in the 'Mémoires de l'Académie Impériale de Dijon,' Deuxième Série, tom. v. 1857.[2]

[1] "Bemerkungen über die Fussknochen des fossilen Gürtelthiers (*Glyptodon clavipes*, Ow.)," Abhandlungen d. Konigl. Akad. d. Wissenschaften, 1849.

[2] Under the title "Description d'un nouveau genre d'Edenté fossile renfermant plusieurs

M. Nodot, in his introductory remarks, states that Vice-Admiral Dupetit brought back from Monte Video, in 1846, a great number of fossil bones which had been collected by Dr. Numez on the banks of the river Lujan, and were given to the Vice-Admiral by the orders of the Dictator Rosas. Admiral Dupetit presented most of these remains to the Museum of the Jardin des Plantes in Paris ; but dying before he had disposed of all, his widow bestowed two boxes full of detached dermal ossicles on the Dijon collection. Out of these, by dint of four months' constant toil, M. Nodot reconstructed the carapace.

Subsequent investigations in the store-rooms of the Jardin des Plantes revealed almost the whole of the tail, and many important parts of the skeleton, of what M. Nodot believed to be the same individual animal, mixed up, however, with fragments of *Mylodon*, *Megatherium*, and *Scelidotherium*. Besides these, M. Nodot found the tolerably complete extremity of the tail of another individual of the same genus in the Geological Gallery, and the right half of a lower jaw with the teeth, which he judged to belong to this individual.

The bones which M. Nodot, guided as it would seem chiefly by their colour, identifies as belonging to the same individual with the carapace, are, " the lateral and posterior part of the cranium, the occiput, the meatus auditorius, the zygomatic arch and its long apophysis, three alveoli, and the sagittal crest ; the atlas, the axis, the vertebra of the fifth ring of the tail ; the two femora entire ; the tibiæ and fibulæ anchylosed ; the calcanea ; the astragali ; the other tarsal bones ; the left metatarsus ; the three external toes of the left hind foot ; the left radius ; the ungual phalanx of one of the digits of the fore foot ; and the ungual phalanx of an internal toe of the hind foot." The carapace and the tail are fully described by M. Nodot, who considers their peculiarities sufficient to justify him in establishing for these remains the new genus *Schistopleuron*.

How far he was justified in so doing is a point which must be discussed at the end of this memoir ; but there can be no question that "*Schistopleuron*" is one of the *Hoplophoridæ*, closely allied to *Glyptodon clavipes* ; and hence M. Nodot's descriptions of the mandible, sternum, and femur constitute substantial additions to our knowledge of the organisation of that family.

The mandible is unlike the sketch furnished to Professor Owen, and adopted by him, but very like that which will be described below.

espèces voisines du Glyptodon, suivie d'une nouvelle méthode de classification applicable à toute l'histoire naturelle et spécialement à ces animaux. Avec un atlas de douze planches lithographiées."

The first piece of the sternum and the first two ribs were so anchylosed together as to leave no trace of their primitive separation.

On the 14th of November, 1862, I presented to this Society a "Description of a new Specimen of *Glyptodon*, recently acquired by the Royal College of Surgeons of England," which was published in the fifty-third Number of the 'Proceedings of the Royal Society.' The remains of the specimen, described briefly in this preliminary notice, and, in full, in the present memoir, were presented to the Royal College of Surgeons by Señor Don Maximo Terrero, having been discovered in 1860 on the estate of his brother, Señor Don Juan N. Terrero, which is situated on the banks of the river Salado, in the district of Monte, in the Province of Buenos Ayres, and about eighty miles due south of the city of that name.

No portions of any other animal, nor any duplicate bones, have been discovered among the osseous relics the description of which has been entrusted to me by the authorities of the College of Surgeons—a circumstance which justifies the belief that they all belonged to one and the same animal, and gives them a peculiar value, the more especially as there can be little doubt of the specific identity of the new specimen with the animal to which the skull ascribed by Professor Owen to *Glyptodon clavipes* belongs.

I have thus been enabled to add to what was already known of *Glyptodon clavipes*, descriptions of the most essential peculiarities of the fore part of the skull, the entire palate, the mandible, the greater part of the spinal column, the pelvis, and the complete fore and hind feet, and to announce the existence, in this animal, of a conformation of the spinal column hitherto unknown in the Mammalian, and, indeed, in the Vertebrate series—the last cervical and two anterior dorsal vertebræ being anchylosed together into a single osseous mass articulated by ginglymi with the rest of the vertebral column. As another very remarkable peculiarity of this genus, I have pointed out the extraordinary characters of the pelvis, and the fact that the cuneiform bone in the carpus articulates with two metacarpal bones, the fourth and fifth, while the unciform does not articulate with the fifth at all.

Since the appearance of my paper in the 'Proceedings of the Royal Society,' and indeed not until the months of May and June, 1863, M. Serres, apparently unacquainted with what had been done in these matters, has redescribed the joint between the second and third dorsal vertebræ, though he appears to be still unaware of the existence of the 'trivertebral bone.' In addition, M. Serres makes known the interesting circumstance, that the posterior edge of the

manubrium of the sternum, anchylosed (as M. Nodot had pointed out, though M. Serres does not refer to him) with the first pair of ribs, presents two concave articular facets, by which it was united with the rest of the sternum, which must have presented two convex surfaces adapted to the foregoing in order to allow of a movement of flexion. M. Serres is of opinion that this mechanism is intended to allow of the retraction of the head : " Il est donc vraisemblable qu'au moment du danger, peut-être même que dans le repos ou le sommeil, le *Glyptodon* fléchissait le col pour ramener la tête sous la coupole de la carapace." [1]

In his second communication to the Academy, M. Serres still speaks of the "anchylosis of the first two dorsal vertebræ" only.[2]

Professor Burmeister, Director of the Museum at Buenos Ayres, has been good enough to communicate to me a letter, addressed by him to the Editor of the 'Nacion Arjentina' on the 5th July, 1863, commenting upon a lecture upon the Glyptodon which I delivered before the President and Council of the Royal College of Surgeons, which was published in the Medical Times and Gazette for the 28th of February and 7th of March, 1863, and which contains the substance of the statements previously published in the 'Proceedings' of this Society.

Professor Burmeister affirms that the skeleton of the *Glyptodon* in the Museum of Buenos Ayres is much more perfect than that in the Royal College of Surgeons ; that it has the seven cervical vertebræ complete ; and that the five middle cervical vertebræ are anchylosed together, while the seventh is very delicate and fragile. Under these circumstances, it would appear that Professor Burmeister considers the trivertebral bone (my description of which he confirms) to be composed of the three anterior dorsal vertebræ.

Professor Burmeister is further of opinion that the peculiar mechanism of the joint formed by the trivertebral bone with the rest of the spinal column has not that respiratory function which I have ascribed to it ; but, with M. Serres, he thinks that its object is to allow of the application of the cephalic shield to the anterior aperture of the shield of the body. Professor Burmeister goes on to remark—

" As little do I agree with Mr. Huxley as to the immobility of

[1] "Note sur deux articulations ginglymoïdes nouvelles existant chez le Glyptodon, la première entre la deuxième et la troisième vertèbre dorsale, la seconde entre la première et la deuxième pièce du sternum. Par M. Serres" (Comptes Rendus, May 11, 1863).

[2] "Deuxième Note sur le développement de l'articulation vertébro-sternale du Glyptodon, et les mouvemens de flexion et d'extension de la tête chez cet animal fossile. Par M. Serres" (Comptes Rendus, June 1, 1863).

the ribs, which are wholly wanting in the London skeleton. The skeleton of the Museum of Buenos Ayres has nine ribs, three of which being complete, prove that they possess a certain mobility, moving downwards and backwards on their articulations with the spinal column, as in other Mammalia, but without doubt in a manner somewhat different from the ordinary way."

I am at a loss to divine on what grounds Professor Burmeister ascribes to me the opinion that the ribs are immoveable, and why he affirms that they are wholly wanting in the London skeleton. What I have stated is, that the first rib is immoveable; and so far from the ribs being wholly wanting, I have particularly mentioned their presence,[1] and have alluded to the characters of the first.[2]

Professor Burmeister adds that I am in error in supposing that the dorso-lumbar vertebræ were immoveably united. I believe, however, from Professor Burmeister's own words, that my description is substantially accurate. These words are:—

"There exists a moveable place between the dorsal and the lumbar vertebræ, though the mobility is not so complete as that of the three first anchylosed vertebræ upon the following ones. In this part, the skeleton of Buenos Ayres presents a complete column, formed by eleven vertebræ incorporated into a solid piece, of a very peculiar form, with three crests in the upper part, the two lateral of which bear the ribs in articular excavations. The total number of dorsal vertebræ and of ribs is therefore fourteen. Then follow on these the lumbar vertebræ, all anchylosed together, and immoveably united with the sacrum."

I do not venture to doubt the accuracy of Professor Burmeister's description of the specimen under his own eyes; but nevertheless, as will be seen by and by, it is also true that the account I have given of the *Glyptodon* in the College Museum is quite accurate. And, indeed, as Professor Burmeister admits that all the dorsal and all the lumbar vertebræ respectively were anchylosed together, with only an imperfect mobility at the junction of the two solid masses, I do not see how, in any important respect, his view of the matter differs from mine.

The last criticism which Professor Burmeister offers, refers to what he terms my error in ascribing five toes to the fore foot, when, as he affirms, it possesses only four. Professor Burmeister states that I have figured five toes to the foot of the *Glyptodon* in the lecture already referred to; but he is mistaken; only four toes are there represented, numbered, according to the digits of the typical foot

[1] Proceedings of the Royal Society, *l. c.* p. 317.

[2] Ibid. p. 319.

which they represent, 2, 3, 4, 5. In the 'Proceedings' (p. 325) I have expressly stated—

"The trapezium possesses only a very small double articular facet on its palmar face. If this gave support to a metacarpal, it must have been very small; and as at present neither it nor any of the hallucal phalanges have been discovered, it is possible the pollex may have been altogether rudimentary. In any case the pollex must have been so much smaller and more slender in proportion than that of *Dasypus*, that the animal must have had a practically tetradactyle fore foot."

The errors, therefore, to which Professor Burmeister adverts appear to me to arise to a great extent from his not having rightly comprehended my statements; and in part, it may be, from our having to deal with different objects.

PART II.—*Description of the Skeleton of* Glyptodon clavipes, Owen, (Hoplophorus Selloi, Lund ?).

The materials which have been available for the following description of the osteology of *Glyptodon* are, in the first place, the skeleton referred to in the previous section as having been presented by Señor Terrero to the Royal College of Surgeons; secondly, the detached parts which have been already described by Professor Owen and are now contained in the Museum of the Royal College of Surgeons; thirdly, some fragmentary specimens in the British Museum; and fourthly, photographs of a skeleton of *Glyptodon* in the Museum of Turin. The two latter sources of information, however, are of altogether secondary importance, and will be adduced merely in confirmation of the results obtained from the study of the two former series of materials,—in treating of which, I shall speak of the fragments of *Glyptodon clavipes* described by Professor Owen as the "type specimen," and of the skeleton presented by Señor Terrero as the "new specimen."

§ 1. *Description of the Skull of* Glyptodon clavipes.

In the new specimen [1] the anterior part of the skull, from a line drawn transversely, immediately behind the zygomatic processes, to the anterior end of the snout, is in a remarkably good state of preservation—the boundaries of the anterior nares, the antero-lateral parts of the maxillary bones, the nasal, and the fore part of the

[1] Plate IV. [Plate 5] figs. 1 and 3, Plate V. [Plate 6] and Plate VI. [Plate 7] figs. 1, 2, 4, and 5.

frontal, bones being quite uninjured. Behind the imaginary transverse line in question this cranium is very imperfect—the entire roof and sides, and the greater part of the base of the skull being absent, while a small portion only of the sphenoidal region is preserved.

Of the facial bones, those entering into the palate are preserved almost in their entirety, and one ramus of the lower jaw is nearly complete. This skull therefore supplies almost all those parts which were wanting in the cranium of the type specimen, in which the whole of the roof of the skull, from the nasal bones to the supra-occipital inclusive, most of the exoccipital, alisphenoidal, and orbitosphenoidal regions of the lateral walls, and of the basioccipital, basisphenoidal, and presphenoidal parts of the base, together with the temporal bones, are in good condition, while the premaxillary, maxillary, and palatine bones, with the mandible, are absent.

In order to give a tolerably complete view of the structure of the skull, I shall, in the first place, describe that of the new specimen; I shall next proceed to a comparison of the parts common to this fossil and the skull of the type specimen, in order to demonstrate the specific identity of the two; and then I shall endeavour to supply what is wanting in the new specimen by information derived from the study of the type.

The skull of the new specimen of Glyptodon clavipes.—The anterior nares have a trapezoidal form, the upper of the two parallel sides of the trapezoid being nearly three times as long as the lower, so that the two lateral boundaries converge from the roof towards the base of the nares (Plate VI. [Plate 7] fig. 1).

The upper boundary of the anterior nares is formed by the anterior edges of the thick nasal bones, which are bevelled obliquely from below upwards, and so rounded off laterally that the contour of the two forms a large arc of a circle, the chord of which measures 3·4 inches (Plate IV. [Plate 5] fig. 1). The upper surface of each nasal bone is rough and perforated by many vascular foramina, which open forward; and the two nasal bones are separated by a suture, which can be traced backwards in the middle line for 2·2 inches, and then comes to an abrupt termination. I presume that the extent of this suture indicates the distance to which the nasal bones reach backwards; but there are no traces of the nasofrontal, or nasomaxillary sutures. The middle of the under surface of each nasal bone presents a strong, rounded, longitudinal ridge, on each side of which there is an equally distinct concavity, and the apposed slightly thickened inner edges of the two nasal bones form a third,

less marked, median ridge. The expanded upper edge of the perpendicular plate of the ethmoid embraces this middle ridge, while the nasal turbinal bones are continuous with the ridges on each side of it (Plate VI. [Plate 7] fig. 1).

A well-marked notch, or sinuosity, separates the upper from the lateral contour of the anterior nares ; and, about an inch below this, the inner surface of the outer wall of the nostril exhibits a rounded elevation or thickening. Still more inferiorly, the wall of the nasal cavity is somewhat excavated, so as to present a thin anterior edge, which passes into the trough-like lower boundary, constituted by the palatine portions of the præmaxillæ. These are separated throughout their whole length in the middle line (a distance of rather more than an inch) by a fissure less than one-tenth of an inch in diameter posteriorly, but twice as wide in front, the præmaxillæ becoming more distant by the divarication of their anterior and internal angles. The thick and rough anterior edges of the præmaxillæ diverge obliquely from one another, both forwards and outwards and upwards and outwards, at a very obtuse angle, the interval between their anterior and external terminations amounting to 1·5 inch (Plate IV. [Plate 5] fig. 3). Viewed laterally, the anterior ends of the nasal bones are seen to project about half an inch beyond the upper part of the lateral boundary of the nares, which slopes upwards and backwards with a slight forward concavity from the palatine portion of the præmaxilla (Plate V. [Plate 6] fig. 1).

The nasal cavity is divided, longitudinally, by a very strong osseous septum, which extends to the posterior end of the premaxillary fissure below, and to within 0·4 inch of the anterior contour of the nasal bones above (Plate VI. [Plate 7] fig. 1). This septum terminates, in front and below, in a thin jagged edge; but above, it expands into a broad plate 1·2 inch wide, presenting a deep and broad notch above, into which, as I have previously stated, the conjoined median edges of the nasal bones are received. The septum is about 2·6 inches high in front; and of this height 2·2 inches, or about five-sixths, is formed by the perpendicular plate of the ethmoid, while the rest belongs to the vomer (*Vo.*). The ethmoidal plate is thin in front, thicker in the middle, and thin again posteriorly. The lower half is somewhat excavated on each side, from above downwards ; it ends in an inferior edge, or rather surface, 0·7 inch in diameter, anchylosed with the upper edge of the vomer, which has, in front, a corresponding thickness. The floor of the anterior part of the nasal cavity (*i.e.*, as far as the level of the fourth alveolus) is concave from side to side, and convex from before backwards, its

convexity corresponding with, but being much more strongly marked than, the concavity of the arched roof of the palate.

At about 2 inches from the anterior boundary, a sharp longitudinal ridge commences upon the floor of each division of the nasal cavity, and extends backwards, for a distance of about 1½ inch, to the summit of the arch formed by that floor (Plate VI. [Plate 7] fig. 1, *a*). Each ridge has a sloping convex external face, and a perpendicular concave inner face, 0·2 inch high. Between the latter and the side of the vomer, which is excavated for a corresponding distance from above downwards, lies a canal, a quarter of an inch wide, and open above and at its ends. The floor of each nasal chamber rises gradually into its lateral wall; and upon this, about three-fourths of an inch from the floor, appears a ridge which, at about an inch from the antero-lateral margin of the nostril (or just above the anterior end of the ridge on its floor), passes backwards into the commencement of the inferior spongy bone (Plate VI. [Plate 7] fig. 1, *b*). The root of attachment of this bone to the maxilla is, as usual, a narrow and thin, though long, bony plate, which on its free, or inner, side is continued into two scroll-like lamellæ, an upper and a lower. The upper scroll comes much further forward than the lower, and is a stout plate of bone, slightly concave inwards and convex outwards. In front, it ends in a thin free edge. Superiorly, its margin is folded over outwards, and becomes anchylosed with the lateral wall of the nasal chamber.

The inferior lamella commences about an inch behind the superior one. It is thick, convex inwards and concave outwards, and its inferior edge becomes much thickened as it curves outwards. It is attached to the maxilla by an anterior and superior thin, and a posterior and inferior, much thicker, plate of bone. Three passages, consequently, lie between the lateral walls of the nasal chamber and the 'scrolls' of the inferior turbinal,—an upper, long, narrow, and flattened from side to side; a middle, reniform in section; and an inferior, rounded in contour. The ridges upon the under surfaces of the nasal bones are continued, as I have stated above, into two thick plates of lamellated bone (Plate VI. [Plate 7] fig. 1, *c*), which increase in depth from before backwards and pass into what are, probably, the superior ethmoidal turbinals. Their inner surfaces are flattened and parallel with the sides of the perpendicular plate of the ethmoid. Their outer surfaces, irregularly concave, are separated by but a narrow interval from the concave faces of the superior scrolls of the inferior turbinal bone.

The posterior view of this fragmentary skull (Plate VI. [Plate 7]

fig. 2) affords a further insight into the arrangement of the bones which contribute to the formation of the olfactory chambers. The aspect presented is that of a transverse section taken just in front of the anterior end of the cranial cavity. The comparatively thin posterior part of the *lamina perpendicularis* of the ethmoid (*Eth*) is seen abutting, above, against the frontal bones (*Fr*), and, below, becoming connected with the vomer (*Vo*), the posterior nearly straight free edge of which bone ends on the floor of the nostrils, at the level of the posterior margin of the third molar tooth, and thence slopes obliquely upwards and backwards.

The ethmovomerine plate, however, is not free from all lateral connexion with the turbinal bones, as is commonly the case; but a thin plate of bone, convex forwards and concave backwards, passes, on each side, from the vomer and the lamina perpendicularis to the lateral masses of the ethmoid. The inner surfaces of these are marked by broad flattened grooves, directed forwards and downwards, and separated by sharp ridges, which, in the recent state, were probably produced into delicate plates of bone.

The lower portion of the lateral mass of the ethmoid, which represents the middle turbinal, is continuous with the inferior turbinal. The upper portion, representing the superior turbinal, is similarly continuous with the nasal turbinal. The superior turbinal of each side forms the floor of a considerable cavity (Plate VI. [Plate 7] fig. 2), which is walled in, externally and above, by the frontal bone, and represents a frontal sinus. A rounded dome (*a*) of bone projects backwards from the anterior wall of this cavity, which appears to communicate with the nasal fossæ only by a few foramina, situated around the margins of the dome.

The palate (Plate IV. [Plate 5] fig. 3) is singularly narrow, seeing that its length, measured in a straight line, is about 9½ inches, while its width, between the outer edges of the alveoli, nowhere exceeds 3 inches. The longitudinal contour of the palate is concave anteriorly, convex posteriorly (Plate V. [Plate 6] fig. 1). The crown of the arch of the anterior concave portion is opposite the hinder margin of the third alveolus; from thence the roof of the palate slopes, downwards and forwards, to the free premaxillary edge. From the same point it slopes, downwards and backwards, to the level of the hinder margin of the fifth alveolus, while behind the sixth it ascends, somewhat abruptly, to its posterior termination.

Throughout the posterior two-thirds of its length, the palate is slightly and evenly concave from side to side; but, from the third alveolus forwards, its middle part rises to form a median convexity,

which ends by a rough, abruptly truncated ridge (Plate IV. [Plate 5] fig. 3, *a*), behind the premaxillary fissure. It forms, in fact, the posterior boundary of a transverse fissure ending in a notch, or short canal, at each extremity, which represents the anterior palatine foramen, and which, taken together with the intermaxillary fissure, simulates very closely the form of a T. A deep groove (*b*) separates the raised part of the palate from the alveolar margin, and ends, behind, in a canal which burrows into the substance of the bone opposite the anterior edge of the third tooth on both sides. On the left side, however, the hinder part of the groove is bridged over by a bar of bone. Large foramina are situated, along a line continuing the groove, opposite the third and fourth alveoli; but no such apertures appear in the posterior part of the palate until quite its hinder extremity is reached, when, on each side, two crescentic fossæ (Plate IV. [Plate 5] fig. 3, *c*), wider in front than behind, lie on the inner side of the last alveolus, and appear to separate the palatine from the maxillary bones. They end cæcally above.

The bony palate exhibits no distinct sutures, except a trace of a maxillary suture behind the anterior palatine foramen, and of a palatine suture, which widens behind into a cleft, separating the arcuated, divergent inner and posterior boundaries of the palatine bones. The free surfaces of the bony masses which bound the palate, posteriorly, are so smooth and unbroken, that I suspect the pterygoid bones must be represented in them.

As the palate presents very nearly the same width throughout, while the roof-bones of the skull are always much wider than it, it follows that any vertical section of the skull, perpendicular to its long axis, in the palatine region, would exhibit a trapezoidal form, like that of the anterior nares—the predominance of the upper side over the lower being still more marked. But in the antorbital region the roots of the zygomatic processes are so large, and stand out so much from the sides of the head, that the skull, viewed in front, looks almost like a cube, with its lower face produced forwards and downwards into a truncated wedge (Plate VI. [Plate 7] fig. 1). The only trace of a suture visible upon any part of the sides of the facial wedge is an almost obliterated one (Plate V. [Plate 6] fig. 1, *a*), which runs from a slight notch, opposite the level of the anterior palatine foramen and in front of the first alveolus, upwards and slightly backwards, and marks off the ascending process of the præmaxilla from the maxilla. This ascending process, very narrow in the middle, widens above and joins the nasal bone, so that the circumference of the anterior nares is completed by the præmaxillæ and nasal bones only.

Opposite the second and third alveoli, the maxillary bone, as I have stated above, widens out and expands into the root of a stout zygomatic arch, whence a process, nearly 6 inches long by 2 inches wide, passes directly downwards. The process is much flattened from before backwards (Plate VI. [Plate 7] fig. 1), and is arched from above downwards (Plate V. [Plate 6] fig. 1), so as to be convex in front and concave behind. Its inner edge is thick and rounded, except towards its termination, where it presents some slight irregularities or digitations. The outer edge is comparatively thin and rugose; it is bevelled off inferiorly, and more obliquely on the right side than on the left. The inner part of the front face of the process looks almost directly forwards, and is very smooth; but the outer part of that face looks outwards more than forwards, and is rugose (Plate VI. [Plate 7] fig. 1). The hinder, concave face of the process (Plate VI. [Plate 7] fig. 2) is divided by an oblique ridge (*b*), which passes from its superior and external to its inferior and internal angle into two areæ—an inner, smooth, and an outer, rough and tuberculated. The superior and external part of the process, where it was doubtless continued into the zygoma, is evidently fractured. The root of the zygoma is perforated near its origin by a large, oval, infraorbital canal, the lower edge of which is rather more than an inch distant from the lower margin of the root of the zygoma. The canal is short, and is directed forwards and outwards.

The lachrymal foramen is a round aperture, placed upon the anterior edge of the orbit, 1·6 inch above the infraorbital canal (Plate V. [Plate 6] fig. 1, *b*).

The internal walls of eight alveoli, on each side, are preserved. The external walls of the anterior four upon the left side, and of the anterior three upon the right side, are almost entire; but, posteriorly, the external walls of all the other alveoli, upon each side, are broken away (Plate V. [Plate 6] fig. 1).

Measured in a straight line, the eight alveoli occupy a space of 8 inches, and each alveolus is, on an average, 0·9 inch long. The teeth which occupy the alveoli are sensibly equal in long diameter; but the anterior tooth is much narrower than the others, measuring only 0·35 inch in this direction, while the other teeth have a transverse diameter of 0·6 inch, or nearly double that of the first.

None of the teeth are entire upon the right side. Of the left series, the crowns of the first, third, fourth, and sixth are in very good condition, while the second is much damaged; of the fifth, only the middle lobe exists, and of the seventh only the two anterior lobes (Plate IV. [Plate 5] fig. 3).

The alveoli are exceedingly long, and the outer walls of the third and fourth, on each side, are so much broken away, that the whole length of their alveoli can be observed and measured. The fourth is 4·5 inches long, and bends outwards and forwards as it passes upwards, to terminate nearly on a level with the lachrymal foramen. The tooth which filled the alveolus must have had a corresponding length and curvature; for the two longitudinal ridges of bone, which partially subdivide the alveolus into three chambers near its free end, are continued quite up to its closed extremity, and are lined by a shell of dental substance, which gradually thickens below and becomes continuous with the body of the tooth (Plate V. [Plate 6] fig. 1, 4, 4′).

The third alveolus presents the same general curvatures as the fourth, but is inclined somewhat further outwards at its upper end, which lies close to, and about an inch above, the hinder end of the infraorbital foramen.

The wall of the upper end of the first alveolus has been broken through on the right side. It lies on a level with the upper edge of the infraorbital foramen, and immediately behind the premaxillary suture.

From what remains of the hinder alveoli and teeth, I suspect they become more and more nearly straight posteriorly.

The external vertical contour of each tooth must be very similar to that of the maxillary surface between the upper end and the edge of the alveolus.

The lateral faces of all the teeth are divided by two longitudinal grooves, placed opposite to one another on the two sides of each tooth, into three lobes.

In the first tooth these grooves are very shallow, so that the thickness of the tooth, between the grooves, is far greater than the depth of a groove. In all the other teeth, the thickness of the teeth between the grooves, or of the isthmus by which the lobes of each tooth are connected, is much less than the depth of a groove.

The view of the palate (Plate IV. [Plate 5] fig. 3) shows that lines following the planes of the anterior surfaces of each of the four anterior teeth are directed inwards and forwards; while in the sixth and seventh teeth, if not in all four posterior ones, such lines are directed inwards and backwards. The anterior surfaces of all the teeth, but the first, are concave, the posterior surfaces convex. The grinding-surfaces of all the teeth are directed a little outwards as well as downwards. Each surface is ridged in the middle and surrounded by a thin raised margin, and the general arrangement of

the ridges is such that one is median, traversing the longitudinal axis of the grinding-surface, and three are disposed at right angles to these, in the longitudinal axes of the three lobes. The transverse ridges are continuous with the longitudinal, where they cut it (Plate V. [Plate 6] figs. 3 & 4).

Sometimes a transverse ridge may be bifurcated at its extremity, or accessory branchlets may be given off from the transverse, or from the longitudinal, ridges.

A large pulp-cavity occupies the upper portion of each tooth; but as its walls begin sensibly to thicken at about the junction of the upper and middle thirds of the tooth, the pulp-cavity diminishes in a corresponding ratio, and, rather below the middle of the tooth, it becomes obliterated.

The Mandible.[1]—The lower jaw of *Glyptodon* is very remarkable, partly on account of the trough-like projection of the symphysis, but more especially by reason of its great height in relation to its length. The height, as measured from any horizontal surface on which the jaw is allowed to rest, to the summit of the articular condyle, is 9·25 inches; while the length, measured in a straight line, from the symphysis to the angle of the jaw, is not more than 10·75 inches. The horizontal ramus is very deep and thick, measuring about 3·25 inches vertically by 1·5 inch in thickness, while the ascending ramus is 3·5 inches wide by about 0·9 inch thick at thickest (Plate V. [Plate 6] fig. 2).

The anterior end of the mandible is 2·9 inches wide and abruptly truncated, ending in a rugose edge, nowhere more than half an inch thick, which, at its extremities, bends round at a right angle into the upper margins of the rami (Plate VI. [Plate 7] fig. 5). These, thick and rounded, ascend somewhat towards the first alveolus, which is 2·25 inches distant from the anterior end of the ramus. The symphysis, 5·7 inches long, appears to be formed by the sutural union, and not by the anchylosis of the rami; but the bone has been so broken that a large aperture occupies the middle of the symphysial space (Plate VI. [Plate 7] figs. 4 & 5).

[1] Leaving aside for the present M. Nodot's "Schistopleuron," the only fragment of the lower jaw of *Glyptodon clavipes* yet described is that mentioned in the Catalogue of the Royal College of Surgeons under "No. 517. A fragment of the anterior part of the left ramus of the lower jaw, including portions of the sockets of the anterior teeth. The first is small and simple, and is situated close to the anterior termination of the dental canal; the second socket shows, by the two prominent vertical ridges on its anterior and posterior walls, that the tooth which it contained had the fluted form characteristic of the genus; the third socket, which is the most complete, differs from the preceding in a slight increase of size, and it shows that the tooth was implanted by an undivided base of considerable length, and of the same size and form as the exposed part or crown."

The exit of the inframaxillary canal is nearly half an inch wide, and is situated 1¾ inch below the upper margin of the jaw, and directly beneath the anterior boundary of the first alveolus. The anterior, or symphysial, contour of the mandible slopes, with a slight forward concavity, obliquely downwards and backwards to the level of the foramen ; and is then continued, almost straight, or with a slight anterior convexity, to a point nearly in the same vertical line as the hinder edge of the third alveolus (Plate V. [Plate 6] fig. 2).

The symphysial face is convex from side to side inferiorly, and gradually widens until, at its hinder end, its breadth amounts to 5·5 inches. Its outer boundary is formed by an obtuse longitudinal convexity, which runs along the middle of the outer face of the horizontal ramus, and dies away, posteriorly, at the commencement of the ascending ramus. From this ridge, or convexity, the summit of which corresponds with the greatest outside breadth of the jaw, the outer surface of the ramus slopes upwards and inwards to its alveolar margin (Plate VI. [Plate 7] fig. 4). The inner face of each horizontal ramus is slightly concave from above downwards, passing, in front, into the excavated upper surface of the symphysis.

The general contour of the anterior half of the alveolar margin of the mandible is slightly convex upwards, in correspondence with the concavity of the opposed region of the maxilla (Plate V. [Plate 6] fig. 2). The posterior half of the same margin is broken away ; but it may be assumed that it was concave upwards, answering to the downward convexity of the hinder part of the maxillary alveolar edge.

The inner edges of the alveolar margins of the two rami are 2 inches apart. In the left ramus the series of alveoli is tolerably well preserved for 5½ inches, or to a point behind the anterior edge of the ascending ramus. From the character of the broken surface behind this point, however, it is obvious that the series of alveoli was continued along the inner surface of the ascending ramus, very nearly to the angle of the jaw, and considerably behind a line let fall perpendicularly from the articular condyle—an arrangement which, so far as I am aware, has no parallel among *Mammalia* (Plate VI. [Plate 7] fig. 5).

As the whole length of the series of mandibular alveoli is about 8 inches, it is probable that the number of teeth was the same below as above, or eight on each side.

The external surface of the perpendicular ramus of the mandible is rugose, slightly convex from above downwards and from side to side, while its internal surface exhibits a corresponding concavity,

which is exaggerated below by the inward projection of the posterior alveoli, and is divided by an elevation of its surface, which ascends obliquely from the alveolar margin towards the coronoid process, into an anterior and a posterior moiety. The apex of the coronoid process is broken away upon each side, but it seems not to have extended beyond the level of the articular condyle, from which it is separated by only a shallow notch.

The hinder margin of the perpendicular ramus, which is very thin inferiorly, thickens with the rest of the bone superiorly, and ends above in a transversely elongated condyle, which projects further upon the inner than on the outer side of the plane of the ramus (Plate V. [Plate 6] fig. 2^a). Viewed laterally, this condyle has the form of a wedge, the base of which is 0·7 inch broad; its hinder face being slightly concave, while its anterior face, convex from above downwards, and slightly concave from side to side, looks forwards and upwards (Plate V. [Plate 6] fig. 2). It is this face which bears the surface for articulation with the squamosal element of the skull, and is indeed coextensive therewith. The surface in question is 1·25 inch wide from side to side, and 0·6 inch broad or from above downwards, and is tolerably smooth, but not very different from the adjacent parts of the condyloid process.

The remains of five successive anterior teeth are observable in the alveoli of the left ramus of the mandible, and the socket of the sixth is clearly defined. Behind it, for a space of 1·8 inch, the inner wall of the ramus is broken away so completely that no trace of any alveolus is left. On the right side, the bone is nearly in the same state, but at a distance of 7·6 inches from the anterior edge of the most anterior alveolus, I observe a smooth vertically grooved surface of bone, which is situated nearly in the same plane as the outer walls of the other alveoli, and which I conceive to be part of the outer wall of the last alveolus.

The teeth of the mandible present the same trilobed form and other general characters of those of the maxilla, but very few are in a sufficiently entire state to furnish materials for description. The first and second on the left side, and the third, upon the right side, however, have their grinding-surfaces entire, or nearly so (Plate VI. [Plate 7] fig. 5).

The grinding surface of the first tooth (left side) is 0·85 inch long and 0·4 inch wide at widest. It has a very different form from the first tooth of the maxilla, the two posterior ridges of the outer surface being much more developed.

The grinding-surface of the second tooth (left side) measures 0·9

inch by 0·45 inch; its outer ridges and grooves are also the better marked. The posterior surface of the tooth is flat or a little concave, and its plane is directed obliquely outwards and backwards.

The grinding surface of the third tooth (right side) is 1·05 long, and the isthmuses which unite its prisms are much narrower than in the second tooth. Both the anterior and the posterior faces of the tooth are curved. The grinding-faces of all these teeth are inclined a little inwards as well as upwards, reversing the direction of the grinding-faces of the upper teeth.

The mandibular teeth seem to have been nearly straight, without either external or internal concavity. Their long axes are inclined rather backwards as well as downwards. The alveolus of the fourth tooth, on the right side, is laid open; and I judge from it that the fourth tooth must have had a length of about 3½ inches; and the others might have had the same dimensions, except the first, which is certainly shorter, probably not exceeding 2½ inches.

A considerable canal traverses the right ascending ramus from behind and below, upwards, forwards, and outwards. Its external aperture, oval, 0·3 inch wide, lies upon the outer face of the ramus, on a level with the alveolar margin, and rather nearer its anterior than its posterior edge (Plate V. [Plate 6] fig. 2). The inner end of the canal, which is 1·7 inch long, terminates in the broken cancellous structure, on the outer side of what appears to be the remains of the last alveolus.

I cannot certainly discern any remains of a corresponding canal in the left ascending ramus.

All that remains to be described in this skull is a fragment of the basis cranii, consisting of part of the anchylosed basi- and pre-sphenoid bones. The pre-sphenoid (Plate VI. [Plate 7] fig. 2) is remarkable for the strong crest or spine into which the middle of its upper surface is produced, and which was not improbably continued into an ethmoidal *crista galli*. The posterior apertures of the passages for the optic nerves are ellipses, with their long axes directed upwards and outwards; they are about a quarter of an inch in diameter, and are continued into two canals, which are traceable, outwards and upwards, for about an inch in the substance of the orbitosphenoids. On each side, below and external to the optic foramina, are strong grooves which formed the inner portion of the confluent foramen rotundum and sphenorbital fissure. The front face of the presphenoid and the roots of the orbitosphenoids are excavated by deep sphenoidal sinuses.

Comparison of the Skull of the present specimen with that of the

typical Glyptodon clavipes.—The principal parts which exist in both skulls, and may therefore serve as terms of comparison, are, 1, the nasofrontal region of the roof of the skull; 2, the descending zygomatic processes; 3, the alveoli; and 4, the basi- and pre-sphenoid.

1. The resemblances in size and general configuration between the nasofrontal regions of the two skulls are so obvious that I need hardly dwell upon them at any length. The present specimen differs from the type in the more rounded contour of the nasal bones, in the persistence of the nasal suture, in the less rugosity and squareness of the supraorbital prominences, and in the far less marked definition of the temporal ridges; but none of these characters appear to me to have more than an individual importance, and I am inclined to suspect that they depend largely on the less advanced age of the present specimen.

2. The zygomatic processes have the same length (measured from the infraorbital foramen) in each case. They are slightly narrower in the type specimen; in other respects the zygomatic processes of the two specimens do not differ more than those of opposite sides in the same specimen.

3. In the typical specimen the upper ends of the three anterior alveoli, on each side, are preserved; they occupy just the same space as the three anterior alveoli of the present specimen.

4. The presphenoid in the type has the same crest, and the inner ends of the optic foramina are precisely the same distance apart.

When to these correspondences we add that the distance from the front edge of the nasals to the level of the posterior edges of the supraorbital prominences is the same in both skulls, and that the lower jaw of the new specimen would fit very fairly on to the typical skull, it will, I think, be admitted that there is sufficient evidence of the specific identity of the animals to which the two skulls belonged, and that the imperfections of the new specimen may be supplemented by the evidence afforded by the typical example.

Further data as to the Cranial Structure of Glyptodon *furnished by the typical skull.*—Professor Owen ('Catalogue of Fossil Mammalia and Aves,' p. 384) thus describes the fragmentary skull of the typical specimen of *Glyptodon clavipes*:—

"The occipital condyle (*a*) presents a convexity in the vertical direction, which describes more than a semicircle, and is slightly convex transversely, but is narrower in that direction than it is in the *Mylodon*: it is directed in the *Glyptodon* backwards and obliquely outwards. The occipital foramen (*b*) is very large and transversely elliptical; its plane is inclined from below upwards and backwards

20° beyond the vertical line. The anterior condyloid foramen (*c*), though large, is relatively smaller than in the *Mylodon*, and is situated close to the anterior border of the condyle. The depression for the digastric muscle (*d*) is perforated and separated from the condyle by a wider tract of the paroccipital (*e*) than in the *Mylodon*; and the petromastoid (*f*) below the digastric depression presents a rough convexity, bounded posteriorly by a transverse ridge of the paroccipital instead of the hemispherical depression for the articulation of the stylohyoid bone which characterizes the skull of the *Mylodon*. The basioccipital (*g*) presents a median smooth concavity and two lateral rough depressions, which are continued on to the basisphenoid (*h*), and indicate the insertion of very powerful 'recti-capitis antici majores'; the obliterated suture between the basioccipital and basisphenoid forms a rough transverse ridge. The inequalities of this part of the basal region of the skull present a striking contrast to the broad smooth and even tract which the same part forms in the *Mylodon*. The sides of the concave under surface of the basisphenoid are bounded by longitudinal ridges, which have been broken off in the specimen. The petrous bone terminates by a prismatic pointed process in the foramen lacerum (*i*), which here gives passage both to the jugular vein and internal carotid. The foramen ovale (*k*) is circular, and of the same size as the anterior condyloid foramen. The foramen rotundum (*l*) is one inch and a half in advance of the foramen ovale, and opens with the commencement of a deep and long groove, which traverses the base of the pterygoid processes in the direction towards the antorbital foramen. The base of the zygomatic process supporting the articulation of the lower jaw (*m*) is brought much nearer the occiput than in the *Mylodon*, and is separated from the petromastoid by a deep excavation, perforated by wide apertures that seem to communicate with the tympanic cavity. The articular surface for the lower jaw is well defined, narrow in the axis of the skull, much extended transversely, gently convex in both directions. In the skull of a recent Armadillo (*Dasypus octocinctus*) the articulation for the lower jaw is almost flat, and on a level with the roof of the posterior perforated cavity. In the Prionodon (*Dasypus gigas*, Cuv.) the articular surface is slightly concave, and extends longitudinally forwards from the posterior cavity. The zygomatic process of the malar bone bounds the outer and fore part of the surface, and extends forwards in the form of a laterally compressed plate of bone, and in the *Das. sexcinctus* forms a slight angular projection below the antorbital perforation. In the *Glyptodon*, the articulation for the lower jaw more resembles that in ordinary Pachyderms, and is thus

conformable with the deviation from the Edentate structure manifested by the bones of the foot. But the most remarkable characteristic of the skull of the *Glyptodon*, by which it differs from the existing Armadillos and approaches the Megatherioids, is the long and strong process (*n*) which descends from the base or origin of the zygomatic process of the maxillary bone. This process is compressed, but in the opposite direction to that in the *Mylodon*, viz. from before backwards, instead of from side to side; it measures five inches in length from the antorbital perforation, one inch and three-fourths in breadth across the middle: the outer margin is entire, and as if folded back; the lower half of the inner margin is slightly notched, the extremity of the process curves backwards. Both anterior and posterior surfaces bear strong marks of the attachment of muscular fibres.

"The small remaining portion of the maxillary bone on the inner side of this process shows portions of three deep sockets (*o o*) of the same diameter throughout, indicating the implantation of molar teeth by a single excavated base, and showing two longitudinal ridges on both the outer and the inner side, which proves the teeth to have had the same fluted exterior which they present in the lower jaw, and of which the generic name of *Glyptodon* is expressive. The fractured anterior part of the basis cranii shows the large cavities for the olfactory bulbs, and the remains of a very extensive cribriform plate, the organ of smell being very largely developed.

"The posterior, or occipital surface of the skull slopes forward from the plane of the occipital foramen at an angle of 45°; in the small existing Armadillos it is vertical; in the *Glyptodon* it is divided by a strong median vertical ridge, and separated by a sinuous thicker transverse ridge from the upper surface of the skull. The posterior half of this region of the cranium is marked by the ridges bounding the origins of the temporal muscles, which almost meet along the middle or sagittal line. Part of the lambdoidal suture is seen at *p*; the other cranial sutures are obliterated. The temporal fossæ are pierced by numerous large vascular foramina. The anterior parts of the temporal ridges (*q*) diverge to the posterior angle of the supra-orbital ridges. The frontal or interorbital part of the upper surface of the cranium is broad and nearly flat, smooth, and slightly concave at its posterior half, slightly convex, rough, and perforated by vascular foramina at its anterior half. The most prominent parts above the orbits are most rugose, and indicate a more intimate adhesion to the superincumbent osseous dermal helmet. The lachrymal foramen (*r*) is pierced immediately in front of the anterior border of the orbit.

"The difference in the development of the temporal muscles manifested by the *Glyptodon* and Mylodon in the position of the ridges in the fossil cranium indicates a corresponding difference in the power of mastication and in the density of the alimentary substances habitually selected by each species; the greater proportion of hard dentine in the teeth of the *Glyptodon*, and the greater number of the teeth, which appear to have been thirty-two, eight on each side of both jaws, coincide with the characters of the cranium, and support the inferences thence deducible."

It is necessary to make certain additions and qualifications to the above description. If we may be guided in the interpretation of the structure of the auditory region by the analogy of the existing *Euphractus*, the part which is there termed "paroccipital" (Plate IV. [Plate. 5.] fig. 5, *h*) includes the true mastoid; the "perforated depression for the digastric muscle" (Plate IV. [Plate 5.] fig. 5, *f*) is the external auditory meatus; and that which is termed "petromastoid below the digastric depression" (Plate IV. [Plate 5.] fig. 5, *g*,) is part of the tympanic element of the temporal bone. It would appear that, as in *Euphractus*, the tympanic bone sends a process outwards and backwards, the extremity of which comes into contact with the *pars mastoidea*, and so bounds the external auditory meatus externally and below; while it leaves between itself, the proper tympanic *bulla*, and the *pars mastoidea*, an aperture which communicates with the external auditory meatus. The latter is remarkably small for so large an animal. The "bulla," into which it opened, is broken away; but it is probable that a considerable part, if not the whole, of the rugose spaces supposed above to be for the insertion of "recti capitis antici," mark the place where the thick inner walls of the bullæ impinged upon the basioccipital. The *fenestra rotunda* is visible upon the under surface of the *pars petrosa* as an oval aperture 0·15 inch wide, the long axis of which is directed almost transversely to that of the skull. The *fenestra ovalis*, smaller, appears above the *fenestra rotunda*. The proper carotid canal probably traversed the anterior part of the internal wall of the bulla as in the Armadillos; the jugular vein most likely left the skull by a passage between the posterior and internal part of the bulla, the exoccipital, and the periotic.

The large apertures perforating the roof of the cavity which is situated behind the articular facet for the lower jaw, do not communicate with the tympanic chamber. They are probably venous channels, and they communicate internally with the cavity of the skull.

The articular facet for the lower jaw measures 1·8 inch along its

greater, and 0·6 inch along its lesser diameter; its edges are well defined, and it has a somewhat kidney-shape, the hilus of the kidney being turned downwards (Plate IV. [Plate 5] figs. 4 & 5, *e*). The general aspect of the facet is backwards and downwards, so that, when viewed laterally, its plane appears inclined more than 45° to a horizontal line. The long axis of the facet is nearly at right angles to the axis of the skull, but its outer half has a slight inclination forwards and outwards. It will be observed that the direction of this facet corresponds very well with that of the articular facet on the condyle of the lower jaw of the new specimen; and the nature of the articulation is such that the lower jaw must have had a purely hinge-like movement in a vertical plane, the doubly curved upper surface of each row of mandibular teeth being brought, with a simply crushing motion, against the correspondingly curved lower surface of the maxillary teeth in each masticatory act.

The "deep and long groove" into which, in the above description, the *foramen rotundum* is said to enter, requires particular notice. The *foramen rotundum* and the spheno-orbital fissure are represented by a rounded aperture 0·5 inch wide, situated immediately in front and to the inner side of the *foramen ovale*, and separated from it by only a narrow bar of bone. The small optic foramen, in like manner, lies immediately in front and to the inner side of this aperture, separated from it only by the lower root of the orbitosphenoid.

The alisphenoid is prolonged forwards as a broad plate, parallel with the orbitosphenoid, for about an inch; and thus the conjoined *foramen rotundum* and *fissura spheno-orbitalis* are continued outwards and forwards by a wide canal of the same length. Anteriorly, the alisphenoid ends in an arcuated free edge, and so forms the hinder part of the outer lip of a groove open inferiorly, the inner wall of which is constituted by the lateral mass of the ethmoid. The front part of the outer lip of the groove, separated from the other by a slight interval, is formed by a strong descending vertical plate of the frontal bone, ending below in a rugose edge, thicker behind than in front, which sweeps upwards and forwards towards the posterior part of the infraorbital prominence. It ceases at about three-quarters of an inch from that part.

The optic foramina are prolonged into canals directed forwards and outwards, each about an inch long, the anterior apertures of which open on the inner wall of the great passage just described, immediately behind the level of the anterior edges of the alisphenoids.

The optic nerves, which could hardly have been more than 0·1 inch in diameter, and were therefore very slender in relation to the

size of the animal, must have been continued forwards between the frontal plate and the ethmoid for a distance of at least 3½ inches before they reached the eyeball.

Three other apertures are visible in the roof of the groove—one, about as large as the optic foramen, on its outer side, and three-quarters of an inch in front of the proper anterior end of the optic canal. The two others are smaller and situated close together, and rather on the inner side, half an inch in front of the former. These may be the ends of canals for the oculomotor nerves.

The remains of the expanded upper edge of a *lamina perpendicularis*, similar to that described in the new specimen, are visible, attached to the under surfaces of the nasal bones.

The inner surface of the right lateral portion of the ethmoid is marked by obliquely diverging ridges of bone, with which the plates of the inferior spongy bone were doubtless connected.

By combining the new specimen with this it is easy to ascertain approximatively the length of the cribriform plate. The former specimen, in fact, is broken through at a distance of six inches from the anterior end of the snout, but its posterior face does not exhibit any notable part of the anterior wall of the cranial cavity. The same distance (6 inches), therefore, measured off upon the roof of the type skull, should give the position of a line beyond which the cribriform plate certainly did not extend anteriorly. From the point thus defined to the anterior edge of the presphenoid is a distance of 1·75 inch, which must therefore represent the maximum length which the cribriform plate could have attained. The distance from the anterior edge of the presphenoid to the level of the posterior margins of the occipital condyles is 4·5 inches. The cribriform plate is rather shorter in proportion to the base of the skull in the *Glyptodon* than in the ordinary Armadillos, and its anterior part is situated far further back in relation to the antorbital processes.

The proper cranial cavity, or brain-case, is small when compared with the whole size of the skull, if the chambers which lodge the olfactory bulbs are left out of consideration. It is, in fact, only 4·5 inches long, 2·5 inches wide at widest, and about 1¾ inch high at highest. Its greatest width is situated beneath the occipital ridge, whence it narrows towards the olfactory outlet, which is about 1·25 inch wide. The immediate side walls and roof of the fore part of the cranial cavity are formed by a very thin inner table of bone, separated by a wide air-chamber from the denser and stouter outer table. This air-chamber does not appear to extend back beyond a transverse line connecting the two glenoidal facets.

Mr. Flower has obtained a cast of the cranial cavity, from which one is enabled to form an idea of the shape and size of the brain. The proportionally large cerebellum exhibits a prominent vermiform process, and is completely uncovered above by the cerebral hemispheres. The latter are quite smooth, and their upper contour is much arched, while their sides are flattened, and approach one another anteriorly. The absence of convolutions in the brain of so large an animal, together with the small absolute mass of the organ, leads one to suspect a great absence of intelligence in the *Glyptodon*.

MEASUREMENTS OF THE SKULLS.

A. *The new specimen.*	Inches.
Total length of the palate in a straight line	9·50
Width between the inner edges of the alveolar series	1·75
Width between the outer edges of the alveolar series, opposite third tooth	2·95
,, ,, ,, ,, last tooth	2·8
,, ,, ,, ,, first tooth	2·6
Hinder edge of the last alveolus in front of the posterior nares	0·5
Outer edge of the malar process to the centre of the palate	5·5
The extreme breadth of the skull therefore =	11·0
Vertical height of skull from frontal bones to palate at fourth tooth	6·0
From end of outer edge of orbit to the same point on the opposite side	7·2
Summit of the frontal region to the ends of the malar processes	9·5
Mandible:	
Extreme length from the symphysis to the angle	10·7
Extreme height from the summit of a condyle to a flat surface on which the jaw rests	9·3
Depth of the horizontal ramus at the third tooth	3·2
Width at the symphysis	2·9
Width between the inner edges of the alveoli opposite the first tooth (remains the same throughout)	3·1
Width between the outer edges at the same point	3·1
Width between the outer edges at the third tooth	3·25
B. *The type specimen.*	
Extreme length from nasal bones to the level of the occipital condyles	12·7
,, ,, ,, superior occipital ridge	10·5
Breadth at the front part of the orbits	6·8
,, at the interorbital constriction	4·3
,, across the occiput, about	5·8
Height of the occiput	2·6
Distance between the inner edges of the articular surfaces for the condyles of lower jaw	4·25

§ 2. *The Vertebral Column.*

The remains of this very interesting part of the organization of *Glyptodon* are, unfortunately, in a somewhat imperfect state, though enough exists to demonstrate its altogether unique character.

The Atlas.—Of this bone the mutilated right half is represented

in Plate VII. [Plate 8] fig. 1, giving the anterior, and fig. 2, the posterior aspect of the fragment.

The specimen exhibits rather more than the right half of the lower arch, and rather less than the corresponding portion of the upper arch of the bone. The right lateral mass, with its anterior and posterior articular facets, is almost entire, but the transverse process is broken off close to its origin. The inferior arch is a solid bar of bone with a straight upper and a convex lower contour; and somewhat thicker in the middle, both from above downwards and from before backwards, than at the sides. A section taken through the median plane of this part of the bone would have the shape of a spherical triangle; the lower or horizontal face convex, the anterior slightly concave, and the posterior and upper also concave.

The middle of the posterior and upper face of the inferior arch presents an oval articular facet (fig. 2, *a*) for the odontoid process of the axis, which, when entire, must have measured about 1·6 inch in width by 0·8 inch in antero-posterior length. It is slightly concave, both from before backwards and from side to side, and is bounded by a well-defined though narrow ridge. The outer end of this facet is half an inch distant from the inner and lower edge of the articular surface for the odontoid vertebra, upon the lateral mass of the atlas (fig. 2, *b*). This is a reniform surface with its inner and anterior side concave, while the outer and posterior aspect is convex. Its long axis is almost vertical, while the plane of its surface, which is a little concave both from above downwards and from side to side, is directed obliquely inwards and forwards. Lines drawn through the shorter axes of the two articular facets would intersect one another at a point very slightly in front of the anterior margin of the inferior arch. The foramen for the vertebral artery is situated on the outer side of the facet, opposite the junction of its middle and upper thirds, and nearly on the same level as a tubercle for the transverse ligament, situated on the inner side.

The foramen (fig. 2, *c*) leads into a canal which passes directly forwards, widening as it goes, and traverses the root of the transverse process. In front of this it presents a large oblique aperture, by which, however, it does not terminate. Instead of ending, it makes an abrupt turn upwards through the substance of the superior arch of the atlas, parallel with, and equidistant from, the anterior and posterior margins of that part, and ends by an oblique aperture in the outer part of the roof of the cavity of the atlas, and nearer the occipital than the odontoid edge. The upper face of the lateral mass of the atlas presents an elongated, irregular, transverse aperture,

which communicates with the canal, and from the anterior and posterior margins of which broad and shallow grooves are continued.

The articular surface for the occipital condyle upon the anterior face of the lateral mass of the atlas (fig. 1) is much more concave from above downwards than that just described; and as it is neither concave nor convex from side to side, the surface may be regarded as a segment of a hollow cylinder, answering to rather less than half the circumference of such a figure. When the inferior arch of this atlas is made horizontal, this articular surface looks forwards and inwards. The inner and lower edges of the opposite occipital facets of the atlas must have been separated by a distance of about 1·9 inch.

The transverse process of the atlas is, as I have stated, broken off close to its origin; but the cancellated fractured surface, 2 inches long by more than half an inch wide superiorly, proves that the process was flattened from before backwards, and that it arose from the posterior half of the outer surface of the lateral mass of the bone. The surface of attachment of the process is almost perpendicular to that of the axis of the spinal canal, or, at most, has a very slight inclination from above downwards and forwards. The general plane of the process, on the other hand, as exhibited by an upper or an under view, is directed backwards and outwards. There are no means of judging how far the process may have extended outwards.

The Odontoid and immediately-following Cervical Vertebræ.—The fragment of this region of the vertebral column (figured in Plate IX. [Plate 10] fig. 5 from without, fig. 6 from within, fig. 7 from behind, and fig. 8 from below) is composed of the right half of the neural arch of the axis, or odontoid, vertebra, anchylosed together with the arches of the third and fourth cervical vertebræ. It formed the right half of the roof and side walls of the neural canal in this region. The front face of the bone, thick and prismatic, is obliquely bevelled off to a rounded edge, which is concave anteriorly. The outer face is produced above into a tuberosity, the anterior part of which is perforated by a canal which traverses the whole thickness of the bone and opens on its inner face, near its upper end (fig. 5, *c*, fig. 6, *c*). From the tuberosity a small ridge, partly broken away, leads forwards and inwards along the anterior face of the bone. A stouter ridge extends inwards near the posterior margin of the bone, from the same tuberosity. These two ridges were situated upon the proper upper surface of the arch, and probably joined the anchylosed spinous processes.

The lower part of the outer face presents a broken surface with

the outer terminations of three canals (figs. 5 & 8, *d*, *e*, *f*), the inner ends of which are visible on the inner or under surface of the bone (fig. 6, *d*, *e*, *f*) as they traverse its thickness obliquely from within outwards and downwards. The hindermost of these canals (*d*) is wide below, but narrows into a fissure above. The second, or middle, foramen (*e*) is wider, oval, and looks more downwards. The third (*f*) is much smaller than either of the other two. On the inner face of the bone (fig. 6) the aperture of the posterior canal (*d*) is longest. The middle canal opens upon nearly the same level; but the third, or anterior, canal takes a much shorter course through the bone, and thus its inner end is on a level below the others.

The aperture of the middle canal is situated at about the same distance from the anterior margin of the bone as the inner end of that canal (*c*, *c'*) which, I have stated, opens externally upon the tuberosity. A little aperture (*g*) in the same line with these two leads into the substance of the bone, and seems to have no external outlet. Lines drawn through the three apertures referred to, mark off an anterior segment of the bone from a middle segment, which is defined, by a line drawn from the inner end of the posterior canal below to another small aperture (*h*) above, from a hinder segment.

The posterior face of the bone exhibits, below, a large round aperture (fig. 7, *a*), leading into a passage which traverses the posterior canal just described, and debouches into the middle one.

Immediately beneath this foramen is a small concave articular surface, apparently a fragment of a much larger one.

Superiorly and internally the posterior face of the bone presents a deep fossa (fig. 7, *a*), bounded above and internally by a concave articular facet, the long axis of which is directed almost at right angles to the long axis of the bone.

The facet in question I take to correspond with the posterior oblique process or "post-zygapophysis" of the fourth cervical vertebra. The foramen on the posterior face is the aperture of the canal for the vertebral artery. The facet below it is part of an articular surface upon the inferior or "capitular" division of the transverse process, which is characteristic of the cervical vertebræ in Armadillos; and the middle and posterior canals are the intervertebral foramina for the third and fourth cervical nerves. The upper and inner foramina and canals represent the remains of the primitive interspaces between the several arches. The anchylosed spinous processes, and the bodies of the three coalesced vertebræ, are completely broken away, so that nothing can be said regarding their characters.

The fifth and sixth Cervical Vertebræ.—No remains of the fifth

and sixth cervical vertebræ have been discovered among the bones sent by Señor Terrero.

The " Trivertebral bone," or anchylosed seventh Cervical and first and second Dorsal Vertebræ (Plate VII. [Plate 8] figs. 3, 4, 5, 6).—The three vertebræ which enter into the composition of this singular bone are very much depressed from above downwards, so that the neural canal is more than twice as wide as it is high; while the greatest depth of the whole bone, leaving the spinous process out of consideration, is hardly a fourth of its width. The inferior face of the bone is deeply concave from side to side; and as the floor of the neural canal is also concave, the part which corresponds with the centra of the anchylosed vertebræ has the form of a broad thin arched plate, thinnest in the middle. The superior arches of the vertebræ, which constitute the roof of the trivertebral bone, follow, in a general way, the contour of its floor; but they are much thicker; and, posteriorly, the roof of the trivertebral bone is produced, upwards and backwards, into a very thick short process, which probably represents the spinous processes of the two anterior dorsal vertebræ. The lateral parts of the trivertebral bone, which represent the anchylosed transverse processes of the vertebræ, are very thick and stout, especially in front. Viewed from above, or laterally, they are seen to be marked out by excavations into three portions, one for each primitive vertebral constituent of the bone. With the lateral excavations the heads of the two anterior ribs articulate.

So much for the general characters of this bone. A front view (Plate VII. [Plate 8] fig. 5) exhibits the following features, worthy of more particular description. The lateral mass, which represents the transverse process of the first of the three vertebræ, presents an elongated oval articular facet (*a*), convex from above downwards and looking almost directly forwards, its long axis being horizontal and at right angles to the axis of the spinal canal. The facet is 1·8 inch long by 0·9 inch maximum height.

This articular facet is separated by a deep groove, into the bottom of which a large canal (*d*) opens, from two other articular surfaces (*b*, *c*), placed one immediately above the other, and also parted by a deep channel, which may be regarded as an internal branch of the groove.

The lower articular face (*c*), almost flat, looks inwards and forwards; and its long axis, which continues the direction of the floor of the neural canal, is inclined from above downwards and outwards.

The upper facet (*b*), also flat, and elongated transversely, looks directly upwards. Its inner end is nearer the lower facet than its

outer end; and a well-marked fossa or depression lies behind it. The upper articular surface certainly answers to the anterior oblique process or "prezygapophysis" of the seventh cervical vertebra. The nature of the lower and of the outer facet will only become obvious when the characters of the cervical vertebræ of recent Armadillos have been explained. The anterior face of the spinous process of the trivertebral bone exhibits two ridges, each convex towards the middle line, which divide the face into a middle and two lateral areæ.

The upper face of the bone (Plate VII. [Plate 8] fig. 3) presents three pairs of foramina, terminating internally in canals which lead into the spinal canal, and externally opening into recurved grooves on the surface of the bone. The middle apertures are the largest, and the corresponding grooves more strongly defined and wider. The posterior apertures are smallest, and are situated quite close to the hinder margin. The surface of the bone between these apertures is rough and irregular. The margins of this face of the bone are produced into three processes which alternate with the foramina. The hindermost of these processes is the largest, and ends in a point which is somewhat recurved and bent down.

A side view of the trivertebral bone (Plate VII. [Plate 8] fig. 6) shows that these processes are continued into irregular vertical ridges, between which two fossæ are enclosed. Of these the anterior is much deeper and more capacious than the other. It is an irregular cavity subdivided by a vertical ridge into two, each of which presents a somewhat deeper fossa at its inner and lower end.

The second, shallower, fossa, which lies between the hinder face of the middle process and the front face of the posterior process, presents an elongated irregular articular facet on its anterior wall, and a more rounded articular surface on its posterior wall.

The second rib is received into this fossa, and articulates with both these facets.

The posterior face of the third process presents a small, slightly concave, oval articular face on its lower half, with which the third rib was doubtless connected.

The posterior aspect of the trivertebral bone (Plate VII. [Plate 8] fig. 4) presents for notice, besides the features already mentioned, several others. The neural arch of the hindermost vertebra of the three overhangs; and its under face exhibits two oval slightly concave articular faces (*a*, *a*), the posterior oblique, or "postzygapophysial," surfaces of the second dorsal vertebra. These, however, are not carried upon distinct processes. The great spinous process seems completely to fill up the interval which properly exists between

the postzygapophyses. The posterior face of this process is slightly excavated in the middle of its lower half. Its sides are also a little concave, so that the top swells out into a sort of knob with overhanging margins.

The posterior part of the floor of the trivertebral bone is broken away; but the hinder face of each lateral mass exhibits a transversely elongated articular surface (*b*, *b*), concave from above downwards, so as to resemble a segment of a hollow cylinder, the axis of which is directed from within outwards and very slightly backwards.

The inferior face of the trivertebral bone presents the arched surface, flatter behind than in front, of the continuously ossified central portions or bodies of the vertebræ, and, external to these, two pairs of apertures which perforate this face of the bone at its outer margin. The anterior of these apertures is very much larger than the posterior, and corresponds with the inner end of the middle transverse process, opening just behind the inner end of the first rib. Strictly speaking, the foramen seen upon the front face of the bone (Plate VII. [Plate 8] fig. 5, *d*) forms one of this series of foramina (all of which are the terminations of short passages leading into the spinal canal); so that, as upon the upper, so on the under surface of the trivertebral bone, there are three pairs of foramina in communication with the spinal canal, and of these the middle pair are, in each series, the largest.

The homologies of the three vertebræ which compose the trivertebral bone are determined by the implantation of the head of the first rib into the great fossa between the lateral processes of the first and second. The vertebræ which yields the anterior wall of the fossa is clearly the last cervical, and that which furnishes the posterior wall is the first dorsal. Hence the trivertebral bone is composed of the last, or seventh, cervical and the first and second dorsal vertebræ.

The remaining Dorso-lumbar Vertebræ.—Of these vertebræ thirteen are preserved. The anterior twelve have plainly been immoveably united together into a continuous arched tunnel or tubular bridge of bone, partly by anchylosis and partly by the manner in which their apposed surfaces interlock (Plate VIII. [Plate 9] figs. 1–7).

The four anterior vertebræ (figs. 1, *d. l.* 3, 4, 5, 6) are so completely anchylosed together that almost all traces of their original distinctness are lost. Persistent sutures, of a character intermediate between a "harmonia" and a serrated suture, separate the fourth vertebra (*d. l.* 6) from the fifth, and the latter from the sixth; but the sixth and the seventh (*d. l.* 9) are completely fused into one bone. Between the

eighth and ninth vertebræ a suture is interposed, and also between the ninth and the tenth, at least on the left side. The tenth and the eleventh (*d. l.* 13) are completely anchylosed above, while the suture seems to have persisted below.[1]

Thus far, no trace of distinct articular processes is visible upon these vertebræ; but the hinder face of the eleventh vertebra (*d. l.* 13) presents certain irregular elevations and depressions, which interlock with corresponding ridges and cavities of the anterior face of the twelfth vertebra. The hinder face of the twelfth (*d. l.* 14) and the front face of the thirteenth vertebra (*d. l.* 15) are in like case. I shall return to the consideration of the character of these irregular articular elevations and depressions after describing the general form of the vertebræ.

In all but the first, second, third, eleventh, and thirteenth vertebræ, the parts representing the vertebral centra are broken away, but, when they remain, they are so similar to one another that their form was, doubtless, essentially the same throughout. Each centrum is a comparatively thin bony plate, bent so as to be convex downwards and concave upwards, and presenting a much flatter curve in the anterior than in the posterior part of the column. In front, the central plate is not more than 0·1 inch thick in the middle, but it becomes thicker posteriorly, so that the centrum of the eleventh vertebra is 0·45 inch thick; that of the thirteenth vertebra is 0·1 inch thinner. At the sides and above, the curved central part of the vertebra passes into the lateral processes and upper arches, which last are slightly concave downwards in the first vertebra, flat in the middle vertebræ, and somewhat arched again in the thirteenth. The contour of a transverse section of the spinal canal is a transversely elongated oval in the first vertebra (fig. 3), is more nearly round, but flattened at the top, in the middle vertebræ (*d. l.* 12), and is a vertically elongated oval in the thirteenth vertebra (*d. l.* 15).

The spinous and transverse processes of the vertebræ are represented by three crests or ridges of bone. One of these (Plate VIII. [Plate 9] fig. 2, *a*, *b*), vertical, and situated in the middle line of the dorsal surfaces of the arches of the vertebræ, represents the spinous processes; while the lateral crests (*c*, *c*), directed obliquely

[1] It is convenient to speak of the first, second, &c. of the thirteen vertebræ which succeed the trivertebral bone; but it must be recollected that the first of these is the third of the dorso-lumbar series, the second the fourth dorso-lumbar, and so on, the number of any one of these vertebræ in the dorso-lumbar series being always greater by two than its number reckoned as one of the thirteen. In order to avoid confusion in describing each vertebra, I shall occasionally give after it its number in the dorsal lumbar series, *e.g.* (*d. l.* 3), (*d. l.* 6), by which it is indicated in the figures.

upward and downwards, answer to transverse, accessory, and mammillary processes. As the latter ridges become directed more upwards towards the hinder part of the dorsal region, the total width of the column lessens, and the grooves between the middle and the outer ridges become deeper in the same direction. Thus, anteriorly, the column is fully six inches broad, while at the eleventh vertebra the distance from one external ridge to another is hardly half this amount.

The first vertebra (*d. l.* 3) is as broad and depressed as the trivertebral bone. Viewed in front (Plate VIII. [Plate 9] fig. 3), the neural canal is seen not to take up more than one-fourth of the face of the bone, the rest of which is occupied by two broad expanded transverse processes, directed very slightly upwards as well as outwards. The under half of each of these processes presents an elongated articular facet (*a*, *a'*), convex from above downwards, slightly concave from side to side, which corresponds with, and is received into, the concave articular surfaces upon the hinder face of the trivertebral bone.

Seated upon the upper face of the neural arch are two other oval articular surfaces (*b*, *b'*), which answer to the postzygapophysial surfaces upon the under surfaces of the hinder part of the neural arch of the trivertebral bone.

The inner part of each of these articular faces is convex in all directions; the outer is concave from side to side, convex from before backwards; behind each lies a transverse fossa.

The outer ends of the transverse processes are obliquely truncated, and each presents two articular facets, an anterior and inferior, larger, and a posterior and superior smaller, which articulate with corresponding facets upon the capitulum and tuberculum of the attached rib. A well-marked notch separates the hinder face of the transverse process of the first from that of the second vertebra; and the intervertebral foramen is situated on the same level as this notch, on the one hand, and the anterior inferior facet, on the other, or about halfway between the upper and lower faces of the bone.

The transverse process of the second vertebra (*d. l.* 4) presents two oval articular facets for the head of a rib, more nearly equal and more nearly on a level than those of the first vertebra. The transverse process of the third vertebra is broken on the left side; but on the right side, traces of an elongated costal facet are visible.

The ends of the lateral ridges representing the transverse processes of the fourth, fifth, sixth, and seventh vertebræ are broken away.

In the eighth, ninth, tenth, and eleventh vertebræ (Plate VIII. [Plate 9] fig. 7, *d. l.* 10, 11, 12) they are preserved on the left side, broken away on the right; on the twelfth vertebra the corresponding ridges are broken on both sides.

I find no trace of articular surfaces for ribs on the lateral ridge continued along the eighth, ninth, tenth, and eleventh vertebræ, which, as I have stated, is entire on the left side; but the upper and inner surface of the ridge is rounded and marked by longitudinal striations (fig. 7). The outer surface is rough and irregular, opposite the anterior part of each vertebra, and raised into an irregular tubercle posteriorly.

The spinous processes of all the vertebræ are broken short off; that of the first is almost obsolete, being a mere ridge sloping back towards the second, into which it is continued. The anterior edge of the process is so much inclined backwards and upwards as to afford free play to the knobbed head of the spinous process of the trivertebral bone (fig. 2).

The spinous process of the second vertebra (*d. l.* 4) is 0·4 inch thick where it is broken through, and had probably a considerable height. A distinct interval separates it posteriorly from the thin anterior edge of the spinous process of the third vertebra, which is much thinner, and is anchylosed with its successors, as far as the eleventh inclusive, into a long continuous crest; slight traces of the original separation of the several spinous processes, however, are visible at the base of the crest, and they may have been distinct at their apices. The crest gradually increases in thickness to the sixth vertebra (*d. l.* 8) (where it attains 0·75 inch), and then gradually diminishes. The spinous process of the twelfth vertebra (*d. l.* 14) may have been distinct down to its base; and the posterior edge of the thin ridge, which is all that is left of the process, appears to incline upwards and forwards.

The foramina for the exit of the spinal nerves are not intervertebral in the ten anterior vertebræ, but perforate the bony substance of each vertebra nearer its posterior than its anterior boundary. Of these foramina there are two, on each side, for the five anterior vertebræ; one, larger, below the lateral apophysial ridge; and one, smaller, above, or upon, this ridge at the posterior boundary of each vertebra.

The larger foramen approaches the outer margin of the apophysial ridge, or seems to be situated higher up, in each successive vertebra from the first to the seventh. Beyond this point the level of the foramen descends somewhat. The eleventh vertebra (*d. l.* 13)

appears to have possessed a simple intervertebral notch posteriorly, on the left side; but, on the right, a bar of bone is preserved, separating an anterior foramen from the rest of the notch, which receives a process of the twelfth vertebra. The arrangement appears to be the same in the twelfth vertebra (*d. l.* 14); that is to say, the apparent notch has been divided by a bar of bone into an anterior nervous foramen, and a posterior articular fossa.

I have briefly referred, above, to the articular surfaces of the eleventh and twelfth vertebræ, which are exceedingly irregular and distorted, apparently from partial anchylosis and filling up with osseous matter. A notion of their general character may best be obtained by the study of the posterior face of the twelfth vertebra (*d. l.* 14). On the upper part of the neural arch, on each side of the spine of this vertebra, irregular and partially obliterated posterior oblique processes, or postzygapophyses, are discernible. The zygapophysis is separated by a depression, or groove, directed from without obliquely downwards and inwards, from a wedge of bone which terminates the apophysial ridge. Inferiorly and externally, this wedge presents a slightly concave articular facet, separated by a deep fossa from a tuberosity with a rounded surface, which passes down into the body of the vertebra. On the same level as this fossa, there projects from the front surface of the vertebra a triangular process, which fits into a corresponding fossa of the eleventh vertebra. The front face of the thirteenth vertebra (*d. l.* 15), again, presents, on each side of the neural spine, pits, the floors of which answer to the anterior oblique processes, or prezygapophyses; outside of these are ridges, which fit into the fossæ between the postzygapophysis of the twelfth vertebra and the wedge-shaped process; external to the ridges are fossæ which receive those wedge-shaped processes; and external to and below these, again, are the remains of processes which were received into the deep fossæ mentioned above.

Except in the region of these articular processes, neither the anterior nor the posterior ends of the thirteenth vertebra (Plate VIII. [Plate 9] figs. 6 & 7, *d. l.* 15) are entire. Of the spinous process, only the base is left; it thins off anteriorly to a natural edge, which is inclined upwards and backwards, and seems to have been quite free. Posteriorly, it becomes rapidly thicker; but its mode of termination cannot be ascertained. The large nervous foramen perforates the wall of the vertebra, on a level with the articular processes, and bifurcates externally, so that one of its apertures ends above, and the other below, a stout bar of bone (Plate VIII. [Plate 9] fig. 6, *a*), nearly an inch thick, which ends posteriorly in

a raised curved ridge, forming the anterior boundary of a semicircular groove.

The spinal canal in the thirteenth vertebra is, as I have said, oval in shape, the long diameter of the oval (1·5 inch in length) being vertical, the short diameter (1·1 inch) transverse.

As, in the anterior part of the lumbo-sacral region, this canal has a very different shape, it is probable that two or three vertebræ are wanting in this portion of the spinal column.

The Sacrum and Coccygeal Vertebræ.—The "sacrum," composed of anchylosed lumbar, proper sacral, and coccygeal vertebræ, contains at fewest twelve, and perhaps thirteen vertebræ. The centra of the two hindermost lumbar vertebræ, and of the two proper sacral vertebræ, which follow them (Plate IX. [Plate 10] fig. 2), are thin and broad bony plates, flat above, and slightly concave from side to side below, exhibiting a most marked contrast to the semicylindrical form of the same part in the hindermost of the thirteen vertebræ described above. The plane of the plate formed by the centra of the anchylosed lumbar vertebræ is inclined, upwards and forwards, to pass into the general curve of the dorso-lumbar region. The plane of the centra of the two succeeding sacral vertebræ, on the other hand, is horizontal; and it is obvious, from the characters of the rest of the sacrum, that the centra of the following vertebræ, to the end of the sacral region, were arranged in an almost semicircular curve, the chord of which is about 18 inches long (Plate IX. [Plate 10] fig. 3). The posterior face of the hindermost coccygeal vertebra (Plate IX. [Plate 10] fig. 1, *a*) is broad, oval, and very slightly concave, like the face of an ordinary vertebral centrum; but the centrum of the penultimate coccygeal vertebra is much flatter and narrower; and this flattening and narrowing becomes still more marked in the centrum of the antepenultimate vertebra and of that which precedes it, or the fourth from the end. From this point to the two anterior sacral vertebræ the floor of the sacral canal is completely broken away, but there can be little doubt that the missing centra were represented by a broad and flat bony plate.

The neural arches are but imperfectly preserved, except in the lumbar region and the anterior part of the sacrum. They are thin, and are separated by large intervertebral foramina. In the lumbar vertebræ these foramina pass downwards and backwards into grooves which mark the sides of the central plate. Well-defined depressions upon the sides of the sacral crest lead upwards and backwards to the canals which pass between that crest and the ilia.

The four last coccygeal intervertebral foramina are still larger,

and indicate the passage of large nerves to the muscles moving the tail.

The spinous processes of all the vertebræ which enter into the sacrum, up to the fourth from the end inclusively, are anchylosed together into a long and strong osseous crest (Plate IX. [Plate 10] figs. 3 & 4), which expands above, so as to present a broad and very rugged superior face. This crest is 8 inches high in front, but slowly diminishes as it follows the curve of the centra posteriorly, to 5 inches. The spinous process of the penultimate coccygeal vertebra is very thick, but it is broken short off. It was probably not less than 4 inches high, and afforded a middle point of support for the dermal shield between the ischial protuberances (Plate IX. [Plate 10] fig. 1).

The sides of the two anterior sacral vertebræ and the corresponding part of the sacral crest are anchylosed with the inner edges of the iliac bones, so that only a narrow oval space, left between these parts, near the upper edge of the crest, and the small canals above mentioned, allow of any communication between the region in front of, and that behind the ilia.

Behind this point the vertebræ are devoid of transverse processes as far as the fourth from the end. But the antepenultimate had a long and slender transverse process on each side; the penultimate possesses an equally long but much stouter process, and the last coccygeal vertebra has extremely thick processes of the same length. The enlarged distal ends of these processes unite with one another and with the inner surfaces of the ischia (Plate IX. [Plate 10] figs. 1, 2, 4).

Caudal Vertebræ.—No caudal vertebræ existed among the remains of this specimen of *Glyptodon.*

Of the Vertebral Column as a whole.—It appears from the foregoing description that the atlas of the *Glyptodon* was moveable upon the odontoid vertebra; but that the latter was anchylosed with the third and fourth cervical vertebræ into one short bone, moveable upon the fifth cervical; of the fifth and sixth cervical vertebræ no remains exist. The seventh cervical is anchylosed with the first and second dorsal into a single "trivertebral bone," upon the front part of which the sixth cervical was certainly moveable; while the hinder part of it freely articulates with the third dorsal, so that the bone was capable of motion through a certain vertical arc.

Beyond this point, as far as the fourteenth dorso-lumbar vertebra, the vertebræ are so connected by complete, or partial, anchylosis, that it is impossible any motion should have taken place between them;

and it is probable, though not so certain, that the fifteenth dorso-lumbar vertebra was similarly fixed.

Between this and the two hindermost lumbar vertebræ, which are completely anchylosed together and with the sacral vertebræ, there is a hiatus, but the condition of the two latter is not such as to lead to the supposition that the intermediate vertebræ were less firmly united than they.

The free cervical portion of the vertebral column must have been remarkably short, probably not exceeding 8 inches in length, and the cervical vertebræ were most likely arranged in a nearly straight line.

The trivertebral bone and the thirteen following dorso-lumbar vertebræ, when articulated together, form one great curve, concave downwards or towards the visceral cavity, the curve being much sharper in the anterior than in the posterior part of the column. Measured along its curvature, this part of the vertebral column is about 35 inches long.

At the anterior part of the sacral region the lumbar curve passes into the straight line of the two anterior sacral vertebræ, behind which commences the great sacrococcygeal curve, concave towards the cavity of the pelvis. The lumbo-sacral is very nearly as long as the dorso-lumbar region, so that the vertebral column, from the last cervical to the last coccygeal, may be said to form two subequal arches with a common pier, formed by the proper sacral vertebræ.

DESCRIPTION OF THE PLATES.

PLATE IV. [Plate 5].

Figs. 1 & 3. Upper and under views of the skull of the "new specimen" of *Glyptodon clavipes.*

Figs. 2, 4, & 5. Upper, under, and side views of the hinder part of the skull of the "typical specimen" of *Glyptodon clavipes.*

All reduced to one-half the natural size.

PLATE V. [Plate 6].

Fig. 1. Side view of the skull of the new specimen of *Glyptodon clavipes.*

Fig. 2. The left half of the mandible of the same, one-half the natural size.

Fig. 2a. The ascending ramus of the mandible, viewed from behind.

Figs. 3 & 4. Grinding-surfaces of the teeth, of the natural size.

PLATE VI. [Plate 7].

Fig. 1. Front view, and

Fig. 2. Back view of the skull of the new specimen of *Glyptodon clavipes.*

Fig. 3. View of the occipital face of the skull of the "typical specimen."

Fig. 4. Front view, and

Fig. 5. Upper view of the mandible of the new specimen.

All reduced to one-half the natural size.

PLATE VII. [PLATE 8].

Figs. 1 & 2. Front and back views of the fragment of the atlas.

*** The artist has inadvertently inverted each figure, so that the [illegible] of the bone is turned upwards, and *vice versâ*.

Fig. 3. The trivertebral bone, seen from above.

Fig. 4. The trivertebral bone, from behind; *d*, the first rib, in place.

Fig. 5. The trivertebral bone, from in front.

Fig. 6. The trivertebral bone, viewed from the right side.

Fig. 7. The fragment of the first rib of the right side, viewed from without.

Figs. 8, 9, 10. Front, inner, and outer views of the fragment of the third left rib.

PLATE VIII. [PLATE 9].

Fig. 1. The third to the ninth dorso-lumbar vertebræ, viewed laterally.

Fig. 2. The same, viewed from above.

Fig. 3. The anterior face of the third dorso-lumbar vertebra.

Fig. 4. The posterior face of the sixth dorso-lumbar vertebra.

Fig. 5. The anterior face of the twelfth and thirteenth dorso-lumbar vertebræ. It [illegible] mutilated, especially below and on the left side, none of the centrum of the twelfth vertebra remaining.

Fig. 6. The tenth to the fifteenth dorso-lumbar vertebræ, viewed laterally.

Fig. 7. The same, from above.

All reduced to one-half the natural size.

PLATE IX. [PLATE 10].

Fig. 1. Back view of the pelvis of *Glyptodon clavipes*.

Fig. 2. Front view of the same.

Fig. 3. Side view of the same.

Fig. 4. Upper view of the same.

All these figures are reduced to one-sixth the natural size.

Figs. 5-8. Outer, inner, back and under views of the fragment of the anchylosed odontoid, third and fourth cervical vertebræ, one-half the natural size.

a the upper, and *b* the lower end of the bone in each figure, which is reduced to one-half the natural size.

Fig. 3

Fig. 4

Fig. 5

J. Erxleben del. & lith.

W. West imp.

IV

ON THE STRUCTURE OF THE STOMACH IN DESMODUS RUFUS

Proceedings of the Scientific Meetings of the Zoological Society of London, 1865, *pp.* 386–390. (*Read April* [illegible], 1865.)

ACCORDING to Cuvier (Leçons, ed. 2, t. iv. pt. ii. p. [illegible]), the Cheiroptera exhibit three principal forms of stomach, which are related to their varied food. There is the transversely elongated, tubular stomach possessed by those Cheiroptera which live on fruit; the globular stomach, with closely approximated cardiac and pyloric orifices, exhibited by the specially insectivorous Bats; and the longitudinally elongated, conical stomach, with a pyloric caecum, found in those Bats which suck the blood of other animals. By way of commentary on the last proposition, Duvernoy adds (l. c. p. [illegible]) that the stomach of the blood-suckers is "more or less straight and elongated, approaching in form and structure that of the Carnivora;" while at page 33 he writes:—

"In the Phyllostomes the stomach presents two principal forms. The group with bilobed median incisors has it elongated, without any pyloric caecum, but with a very long tubular pyloric part, the pylorus and the cardia being situated at the apex and the base of a long recurved cone. This elongated form, which recalls that of the most voracious Carnivora, is also seen in a species with median, simple, anomalous incisors. In the Vampyre (*V. spectrum*) the stomach is larger and approaches a rounded form, having the pylorus and the cardia closely approximated, though there is a short tubular pyloric portion. In two species of Phyllostomes, with simple median incisors, the stomach is altogether [illegible]lar, with the two orifices approximated, and the caeca lost in [illegible]n cavity."

I find that *Desmodus rufus* presents a fourth kind of stomach which is not only different from all these, but is unlike any form of that organ which has hitherto been observed in the mammalian series.

The gullet (*æ*) is exceedingly narrow, and opens into a transversely elongated tube (*Py*), which passes on the right side into the intestine (*I*, *I*, *I*). The duodenum and the stomach are not outwardly separated by any pyloric constriction; but as the gall-duct (*x*) is inserted at a distance of not more than 0·2 inch from the œsophageal aperture, it is clear that the pyloric division of the stomach is exceedingly abbreviated.

The cardiac division, on the other hand, is enormously elongated, forming a vast cæcum, sharply bent upon itself, and several inches in length (*Ca*, *Cd*). At first this cæcum is not wider than that part of the stomach into which the œsophagus opens; but before it bends upon itself it has fully twice that diameter, and the recurved portion remains wide throughout, dilating, somewhat suddenly, towards its cæcal end, and then slightly narrowing again to its termination.

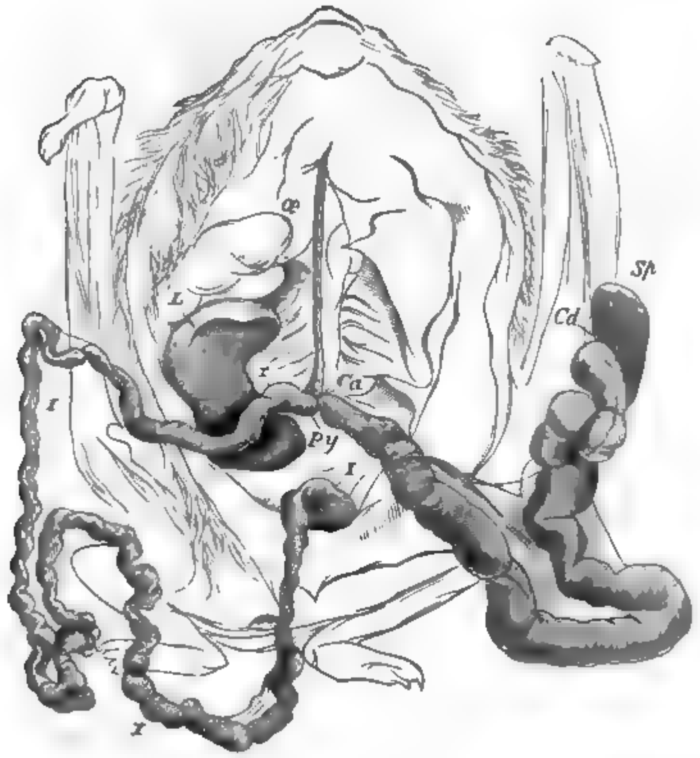
In one specimen which I examined, the body of the *Desmodus*, from the snout to the end of the coccyx, measured 3·2 inches in length; and the intestine, from the pylorus to the anus, was 11 inches long; while the gastric cæcum, straightened out, measured 6·5 inches in length, so that this remarkable diverticulum of the stomach was twice as long as the body, and nearly two-thirds as long as the intestine.

In the 'Zoology of the Voyage of the Beagle,' Mr. Waterhouse, in concluding his description of a species of *Desmodus* (*D. d'orbignyi*), remarks—

"It is desirable perhaps to separate the blood-sucking Bats from the insectivorous species, and place them between the latter group and the *Pteropina* (with which they agree in the large size of the thumb and the rudimentary interfemoral membrane) under a sectional name, which I propose to call *Hæmatophilini*."

It does not quite clearly appear whether by "blood-sucking Bats" Mr. Waterhouse denotes the *Desmodi* only, or whether he includes the blood-sucking Phyllostomes with them. On the former supposition I am disposed not only to agree with Mr. Waterhouse, but even to go so much further as to regard the Desmodine genera, *Desmodus* and *Diphylla*, as constituting, under the title of HÆMATOPHILINA, one of the three primary divisions of the Cheiroptera, the other two being the FRUGIVORA and the INSECTIVORA.

In the FRUGIVORA the nose and ears present no unusual modification. With the exception of *Hypoderma* and *Notopteris* the index digit is provided with a nail. The upper incisor teeth are of moderate size or very small. Before they are worn, the crowns of the



Desmodus rufus.

The thoracic and abdominal cavities are laid open; and the alimentary canal is unravelled and displayed throughout its whole length. From a preparation in the Museum of the Royal College of Surgeons. *œ.* The œsophagus. *Ca.* The commencement of the cardiac sac of the stomach. *Cd.* The blind end of that sac. *Py.* The short pyloric division of the stomach. *Sp.* The spleen. *L.* the liver, with, *x*, the point at which the bile-duct opens into the alimentary canal. *I,I,I.* The intestine. The parts are represented of the natural size.

molar teeth are divided into two ridges by a longitudinal furrow. The pyloric region of the stomach is greatly elongated; the uterus is two-horned.

In the INSECTIVORA, or ENTOMOPHAGA, there are foliaceous developments of the integument of the nose, or of the ears, or of both.

The upper incisor teeth are of moderate size, or are very small. The molar teeth have V-shaped cusps, and do not exceed $\frac{6-6}{6-6}$, or fall below $\frac{4-4}{4-4}$, in number. The index is not only devoid of a nail, but has frequently no bony phalanx at all, and never possesses more than two ossified phalanges. The stomach is either like that of the Carnivora or is globular, the cardiac and pyloric orifices being closely approximated. The uterus is pyriform.

Lastly, in the HÆMATOPHILINA the integumentary appendages of the nose and ears are small or rudimentary. The index is devoid of a nail, and has only a single phalanx. The median upper incisors are enormous, and are alone retained in the adult. The two pairs of lower incisors are small and pectinated. The molars are $\frac{2-2}{3-3}$, with crowns rising to a sharp longitudinal ridge. If the other species of *Desmodus* and *Diphylla* are like *Desmodus rufus*, the œsophagus is very narrow, and the stomach has an immense cardiac cæcum in this group.

The substance of the above remarks was contained in a lecture upon the organization of the Cheiroptera, which formed part of my course at the Royal College of Surgeons during the present year. I was not at that time aware that my friend Prof. Peters, of Berlin, had already noted the anomalous character of the stomach of *Desmodus* in the pages of a work upon the Mammalia which is at present unpublished, but which we may hope will not long remain so; and from a proof-sheet of which I quote the following passage:—

"4. Subfamily *Desmodi* . . . . . The stomach is very small, and has, on the left side (not at the pylorus), an intestiniform appendage 1 to 2 inches in length."

Further, I gather from this proof, and from conversation with Prof. Peters, that he regards *Desmodus* merely as a somewhat aberrant member of the subfamily of the *Phyllostomata*, and not as the type of a primary division of the Cheiroptera. The peculiarities of the dentition of the *Desmodi* are, he considers, foreshadowed by the *Stenodermata*, containing the genera *Stenoderma Chiroderma*, *Sturnira*, *Brachyphylla*, and *Centurio*, the true molar teeth of which are distinguished by having an external cutting, or notched margin, and usually acute cusps on the middle of the masticating surface; while they never have the V-shaped cusps of their allies, and are said to live exclusively on fruits. In several of these genera the total number of molar and premolar teeth does not exceed four on each

side, above and below—a character which is also to be regarded as an approximation towards the extreme reduction observed in *Desmodus*.

Professor Peters's acquaintance with the Bats is so extensive and profound that I feel bound to call particular attention to these views, which substantially constitute objections to the taxonomic suggestions I have ventured to throw out.

V

ON A COLLECTION OF VERTEBRATE FOSSILS FROM THE PANCHET ROCKS, RANIGUNJ, BENGAL.

Memoirs of the Geological Survey of India ; Palæontologia Indica, Series IV. ; Indian Pretertiary Vertebrata, vol. i., pp. 3–24, 1865–85.

THE Collection of vertebrate fossils, from the Panchet rocks, Ranigunj, submitted to me by the Director of the Geological Survey of India, consists of numerous fragmentary, and sometimes rolled, bones, the majority of which are vertebræ, or belong to the limbs. Among these, however, are some teeth and a very small number of portions of crania, with fragments of detached lower jaws.

The nature of some of the specimens can be determined without difficulty. These, which are, for the most part, teeth or cranial fragments, I shall proceed to describe and refer to their systematic position. Afterwards I shall investigate the less definitely characterized remains: and finally inquire what evidence is afforded by the fossils respecting the age of the deposit in which they occur.

I. REMAINS OF LABYRINTHODONTS.

1. *The Labyrinthodont Skull* (Plate VI. [Plate 16] fig. 1).—Of the nature of this interesting and unique fossil, represented of the natural size from above (fig. 1), and from below (fig. 1 *a*), there can, fortunately, be no doubt. It is the fore part of the snout, between the orbits and nostrils, of a Labyrinthodont, the upper surface of which presents the characteristic sculpture and the 'mucous canals' of that group of Amphibia: while the lower face exhibits, in front, the posterior boundaries of the posterior nares ; behind, the anterior boundaries of the great posterior palatine apertures ; and at the sides, the double rows of maxillary and palatine teeth. As in the Labyrinthodonts

generally, the snout is very much depressed in proportion to its length and breadth (figs. 1 *b*, 1 *c*). Above, it is slightly convex from side to side, the central region being flattened, while the sides incline down gradually to the free edges. From before backwards (fig. 1 *c*) it is a little concave, the contour sloping downwards from the orbital to the nasal region. The remains of the anterior margin of the right orbit appear to be traceable, though not very distinctly; but the end of the snout, containing the anterior nares, is broken off. It is very difficult to make out, clearly, the existence of any of the sutures which usually appear in this region of the face. I cannot find any trace of that median suture which ought to divide the two nasal bones; but I think I can discover, upon the right side, those which separate the prefrontal, on the one hand, from the nasal, and, on the other, from the maxillary bone. If I am right in my interpretation, the prefrontal is a large bone, broader behind than in front, and extending from the orbit to beyond the fractured anterior end of the cranium; and so much of the 'mucous canal' as remains, from a fifth of an inch behind its angulation to the anterior end, is excavated in the upper surface of this bone.

These 'mucous canals' are shallow grooves, not more than $\frac{1}{20}$th of an inch wide, which take a very peculiar and characteristic course upon the surface of the fragment of the skull. At its posterior margin they are about 0·25 inch apart, but they approach until, about the level of the anterior margin of the orbits, their distance is diminished to 0·15 inch. They then diverge, curving outwards and downwards, so as to present a concavity externally, until they are half an inch distant. Each, next, bends upon itself forwards at a sharp angle, so as to become parallel with the sides of the snout, and tending slightly towards its fellow, ends at the anterior broken margin.

On the left side (fig. 1 *b*), there is a well-marked groove, nearly parallel with the anterior straight portion of the 'mucous canal,' which seems to follow the junction of the maxillary, prefrontal, and lachrymal bones. On the right side, a corresponding groove is visible, but is far less distinct.

The palatine surface is flat from before backwards, and slightly concave from side to side, the dentigerous surface of both the palatine and maxillary bones projecting beyond the general level. No sutures are distinctly traceable between the vomerine, parasphenoidal, palatine and pterygoid elements, which enter into the formation of this part of the skull. A tolerably deep groove separates the pterygo-palatine from the maxillary dentigerous ridge.

The maxilla is preserved for a distance of 0·9 inch on both sides,

but the fragment of the right maxilla is situated further back than that of the left side. The remains of eight short conical teeth are visible on the left side; but, very possibly, a ninth was situated in a part which is broken away. At least fourteen or fifteen teeth are visible in the fragment of the right maxilla, and they are smaller and more closely set than those on the left side. Thus it would appear that the teeth were smaller and nearer together in the posterior, than in the anterior, part of the maxilla ; but it is remarkable that, so far as the corresponding portions of the two maxillæ are preserved, the teeth do not exactly agree, being smaller and more closely set on the right side, larger and more distant on the left. The largest of the maxillary teeth is about 0·05 inch broad at the base, and 0·1 inch high. The base presents well-defined longitudinal grooves, which become obsolete towards the apex. The teeth are not lodged in sockets, but their broad bases are completely anchylosed with the substance of the jaw.

The palatine teeth form a series which is an inch long, on the right side, where these teeth are best preserved. Ten teeth, situated at tolerably equal intervals, are observable in these series. The apices of all are broken off. The bases of the posterior nine do not exceed $\frac{1}{25}$th of an inch in diameter; but the first tooth is twice as large, resembling the largest of the maxillary teeth.

In its slenderness, this Labryinthodont snout resembles, among known Labyrinthodonts, only *Archegosaurus* and *Trematosaurus*, into the outline of the skull of which last genus, as figured by Burmeister ("Die Labyrinthodonten," Taf. 1), I have fitted it, in the figures 1 & 1 *a*. But it differs from both these genera in the following characters:—

1st. The 'mucous canals,' which in both *Archegosaurus* and *Trematosaurus* sweep outwards and forwards in front of the orbits with an even curvature, are angulated.

2ndly. The anterior ends of the posterior palatine apertures are situated relatively further back, and the long axes of these apertures are more directly in one line with those of the anterior palatine apertures, in the Indian fossil than in either of the European genera.

3rdly. The first palatine tooth is larger relatively to the second, in the Indian fossil than in *Archegosaurus* or *Trematosaurus*.

When so small a fragment of the cranium presents so many differences from the most nearly allied forms, it is quite safe, I think, to regard the animal to which it belongs as the type of a new genus, for which I propose the name of *Gonioglyptus* (γωνία, γλύφω). The species may be termed '*longirostris*.'

2. *Labyrinthodont Mandible* (A).—Sundry fragments of unquestion-

ably Labyrinthodont mandibles occur among the Ranigunj fossils. Of these, I am inclined to think that represented in Plate VI. [Plate 16] figs. 2, 2 *a*, & 2 *b* belongs to *Gonioglyptus*. But I base this hypothesis merely on certain general resemblances of proportion, texture, and sculpture; so that the association of mandible and skull must be regarded as simply provisional.

The specimen figured is the left ramus, lacking, probably, about the anterior half of its length. The whole of the dentary element is gone, what remains consisting of the representatives of the articular (with the supra-angular) and angular portions.

The surface upon which the articular portion received the head of the *os quadratum* (fig. 2 *b*) is set transversely to the axis of the bone, and is concave from before backwards. Internally, this surface is continuous with a deep groove which runs obliquely forwards and inwards. Behind the articular surface, the jaw is prolonged backwards for nearly 0·7 inch, as a process, answering to the supra-angular element, which is sharp-edged above and below, and flattened externally; while internally (figs. 2 *a*, 2 *b*) it is raised into a strong rounded projection.

The outer face of the ramus (fig. 2) is marked by a strong oblique groove, which commences at the upper edge of the (supra-angular) process, just behind the articular cavity, and then, running obliquely downwards and forwards, makes a sharp bend upon itself on the under surface of the ramus, to end abruptly where that surface joins the inner face. Two smaller, more horizontal, grooves lie in front of the oblique one, upon the upper part of which their hinder ends abut (fig. 2). The upper of these is very small, and may be easily overlooked; the lower is obvious enough, and doubtless extended much further forward when the jaw was entire.[1] The focus, or centre, whence the sculpture-lines of the 'angular' element of the jaw radiate is placed about $\frac{1}{8}$th of an inch in front of the recurved anterior end of the oblique groove. Crossing this about its middle, at an acute angle, I find traces of the suture between the angular and articular pieces. The articular is united indistinguishably with the supra-angular element.

Anteriorly, a transverse section of the ramus of the jaw would be four-sided, so that it may be regarded as a four-sided prism. Three of the sides of this are formed by bone; but the upper, or fourth, side is wanting, the dentary element, which should close it, being absent. The outer and the under sides are formed by the sculptured dentary element. The inner wall, quite smooth, exhibits an oval space, such

[1] I find similarly disposed oblique and horizontal grooves upon the outer face of the mandible of a *Labyrinthodon* from the Warwickshire Trias.

as is left between the splenial and supra-angular elements of a Crocodile's jaw. Behind, and below the level of, this aperture a suture can be clearly traced between the angular element and the neighbouring conjoined articular and supra-angular; but, in front, I can find no corresponding suture between the inner wall and the angular. The line seen in this region, in fig. 2 *a*, which looks like a suture, indicates only the commencement of the sculptured face of the angular element.

Three other fragments (one small, of a left ramus; two large, of a right ramus), containing more or less of the articular portions of mandibles, precisely similar to the foregoing in all respects except size, were discovered in the present Collection. One indicated a lower jaw smaller than that described, while the others denoted mandibles at least half as large again. As the small fragment belonged to the same side as the ramus figured, and the large fragments both appertained to the opposite side, it is clear that there is evidence of the existence, in the Collection, of, at least, four distinct individuals of this species.

Labyrinthodont Mandible (B).—The only other considerable portion of a Labyrinthodont mandible in the Collection is the incomplete left ramus represented, of the natural size, in the accompanying woodcuts, from the side (Fig. 1), and from above (Fig. 2). This mandible resembles the foregoing in the oblique groove (*a a*, Figs. 1 & 2) which marks the outer surface of the supra-angular and angular portions of the jaw, and bends back into a sort of loop upon the inferior surface of the latter. As to absolute size, though it is considerably larger than the specimen figured in Plate VI. [Plate 16] fig. 2, the vertical dimensions of the fragments of the larger mandibles of that species fully equal those of the present specimen; but, in other respects, it differs widely from the corresponding ramus of the mandible of *Gonioglyptus*.

The latter, for example, is straight (Plate VI. [Plate 16] fig. 2 *b*), the incurvation of the symphysial extremity towards the opposite ramus having evidently commenced beyond the point at which it is fractured. But, in the present specimen (the ramus of which, in relation to its depth, is shorter than that of *Gonioglyptus*), the symphysial end has obviously begun to bend inwards, indicating that the jaw was shorter, while the head was probably more obtuse.

The inner wall of the present jaw is much broken posteriorly; but the anterior boundary of an oval open space, such as is shown in Plate VI. [Plate 16] fig. 2 *a*, can be made out. In front of it, the inner wall is formed by a continuous plate of bone. Now this front boundary of the oval space is only 1·5 inch from the level of the

articular cavity of the mandible, whereas, in the, absolutely, much smaller jaw of *Gonioglyptus*, the same measurement is 1·7 inch.

Viewed from above (Plate VI. [Plate 16] fig. 2 *b*), the thickest part of the ramus of the mandible of *Gonioglyptus* is just in front of the articular surface; behind this point it narrows evenly to the end of the supra-angular process, the upper edge of which is quite sharp and not incurved. In the present specimen, on the other hand, the outer wall of the ramus swells out, suddenly, just behind the level of the articular cavity, and the upper edge of the supra-angular process, is, as it were, bent in by the development of this projection

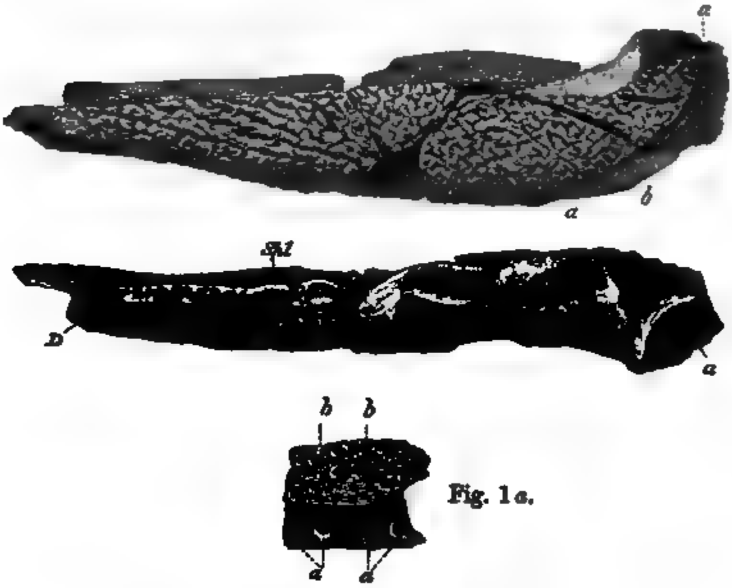


Fig. 1.

Fig. 2.

Fig. 1 *a*.

Figs. 1 & 2. Mandible of *Pachygonia incurvata*, viewed from the side (Fig. 1); from above (Fig. 2). Fig. 1 *a*. a small portion of the upper surface, magnified. *D*, dentary; *Spl.* splenial element of the jaw.

(Figs. 1 & 2). The hinder and upper end of the oblique groove, which terminates immediately behind the articular surface in *Gonioglyptus*, and lies altogether on the outer side of the jaw, here becomes thrown backwards, and appears on the upper aspect of the jaw (Fig. 2 *a*). Much of the supra-angular portion of the mandible is absent, the hinder extremity presenting an abruptly truncated, broken surface (Fig. 1).

In *Gonioglyptus* the whole of the angular and supra-angular (+ articular) portions of the mandible, so far as they enter into its outer wall, are sculptured; but, in the specimen under description, the sculpture on the angular piece ceases above, and in front of, the

lower end of the oblique groove, while the lowermost part of the supra-angular region (*b*, Fig. 1) is also devoid of sculpture. In this respect the present mandible more closely resembles that of the genus *Labyrinthodon* (as exemplified by the Warwickshire species) than that of *Gonioglyptus*.

The dentary piece of this mandibular ramus remains in place for a distance of 1·45 inch, and exhibits the bases of fifteen or sixteen teeth, anchylosed firmly, at tolerably regular intervals, to the bone (Fig. 2, *D*). The base of each tooth is 0·1 inch wide, but hardly more than a third of that amount long, so that it has the form of a transversely elongated oval (*a a*, Fig. 1 *a*). In one instance, however, sufficient is left of the tooth to show that it rapidly narrowed at the sides, and thence soon acquired a nearly round section. Inside the dentary piece there seems to be a distinct splenial element, the limits of which cannot be distinctly traced. It exhibits minute, round, crater-like elevations (*b b*, Fig. 1 *a*), as if (as is the case in some Amphibia and Ganoid fishes) it had given attachment to teeth. The mandible now described certainly belongs to a distinct species from the foregoing; and the tumid enlargement of the supra-angular region is so unusual among the Labyrinthodonts, that I am inclined to regard it as a character of generic importance. The fossil may receive the name of *Pachygonia* (παχύς, γωνία) *incurvata*.

4. *Right lateral thoracic plate of a Labyrinthodont.*—No part of their organization is more characteristic of the Labyrinthodonts than the three sculptured plates which cover, like a buckler, the anterior part of the thorax, and seem to take the places of the 'entosternum' and 'episterna' of the *Chelonia*.

One of the lateral, or episternal, plates, of the right side, of this apparatus is represented in Plate VI. [Plate 16] fig. 8. It is thick at its outer and posterior angle, whence the usual strong process passes at right angles to the plane of the plate (fig. 8 *a*); but it thins off rapidly towards the internal, anterior, and posterior sides. The natural edges are consequently broken away on these sides. The centre of radiation of the fine inosculating sculpture-ridges is close to the outer and posterior angle (fig. 8).

II. Remains of Dicynodonts.

The Dicynodont bones in the Ranigunj Collection are the first relics of those remarkable reptiles which have been found out of South Africa. They seem to have abounded in India, however,

as I have much reason to think that the great bulk of the fossils submitted to me proceed from them. I shall confine myself, in the present place, to the description of those remains the Dicynodont nature of which cannot be doubted. These are fragments of maxillæ and of mandibles, teeth, scapulæ or coracoid bones, and humeri; to which, with a little hesitation, I add part of the roof of a skull. On the species of Dicynodont to which these remains belong I propose to confer the name of *Dicynodon orientalis*.

1. *A Maxilla.*—The worn and shattered fragment represented in Plate II. [Plate 12] fig. 1 consists of part of a right maxilla, with a broken tusk still lodged in its alveolus. The tusk is slightly curved and 2 inches in length, measured in a straight line from one end to the other. It is 0·37 inch thick at its distal, and rather more than 0·4 inch at its proximal end; so that it tapers but very gradually. The narrow extremity of the pulp-cavity is traceable for rather more than half an inch from the proximal end, but there stops, and, for the rest of its extent, the tusk is solid.

2. *A Mandible*—Fig. 3, Plate II. [Plate 12] represents the symphysial end of the left ramus of a mandible, which has all the characters of that of a Dicynodont. Its outer surface is somewhat more concave than the figure makes it appear to be, both from above downwards and from side to side; a well-marked angulation separates the outer from the under surface, the latter being convex, both from before backwards and from side to side; and just above this angulation, and separated from it by a well-defined depression, the outer surface presents, close to the symphysial end, a sharp oblique ridge, above and behind which, and parallel to it, is an indication of another more obtuse ridge. The upper surface of the ramus, 0·3 inch thick and flattened anteriorly, is bordered by two obtuse marginal ridges. Posteriorly, the flattened surface passes into a deepish groove.

I have found three other fragments of the symphysial ends of rami of Dicynodont mandibles, two belonging to the left, and one to the right side. The largest is fully twice the size of the specimen here described.

3. *Dicynodont Teeth.*—The largest specimen of a Dicynodont tooth in the Collection is that represented in Plate I. [Plate 11] fig. 2. It is rather more curved than the one implanted in the maxilla (Plate II. [Plate 12] fig. 1). It is solid at its smaller, or distal, end; while, at the other (fig. 2 *a*), it exhibits an aperture 0·4 inch wide, leading into

a conical cavity, which terminates about 0·8 inch from the distal end.

In section, the tusk is nearly round, or rather would be so, were it not marked by about twelve shallow longitudinal flutings, which convert its contour into an irregular polygon.

Of four young tusks (known to be such, and not merely the apices of fully-formed teeth, by their wide and long pulp-cavities), none of which exceeds an inch in length, the largest, the summit of which is broken, exhibits a similar fluting towards its base. One of these young tusks (Plate II. [Plate 12] fig. 2) has a deformed apex. Two others are slightly worn, so as to present a flattened subapical facet, which is situated in one case on the concave side of the tusk, in the other on its lateral face.

Fig. 3, Plate I. [Plate 11] represents a much fractured specimen, the value of which lies in its giving the general proportions and curvature of the extra-alveolar part of the tusk.

4. *Dicynodont Scapulæ or Coracoids* (Plate V. [Plate 15] figs. 1, 2, & 3).—In his "Report on the Reptilian Fossils of South Africa: Part III. On parts of the skeleton of the trunk of *Dicynodon tigriceps*," published in the seventh volume of the 'Transactions of the Geological Society,' Professor Owen says (page 246), "The bone represented in fig. 2 *s. g*, and fig. 3, Plate XXXIV, is either a scapula or a coracoid."

The bone here referred to is 12 inches long, but otherwise it presents a very close reşemblance to that represented, of the natural size, in fig. 1 of Plate V. [Plate 15].

This exhibits a broad plate-like expansion, which is slightly concave from before backwards on the side presented in fig. 1, slightly convex on the opposite side, and passes by a thick, but flattened, neck into a head terminated by a cup-shaped articular surface. In the specimen represented in fig. 1, the edges of this articular cup are much broken and worn; but in the fragment of a much larger bone of the same side (fig. 2) they are almost entire. This specimen shows that the cup would be four-sided, were it not that the upper side is replaced by the deep notch seen, in the preceding specimen, towards the right margin of the cup. Of the other sides, the left (in fig. 2) is thin-edged, smooth, and concave internally; the inferior and right sides, on the other hand, are thick and rough, and, doubtless, united suturally with some other bone.

On the opposite face to that displayed in fig. 1 (as is especially well seen in the view of the corresponding face of the same bone of a

smaller individual, and from the opposite side of the body, fig. 3) peculiar markings, like broad and shallow excavations, are observed to radiate from above the neck of the bone towards its free edge.

In form, this bone is very unlike any known Saurian scapula, while it much more nearly resembles a coracoid. But, on the other hand, it wants the perforation which is generally found in the latter bone; while among the remains referred to *Dicynodon tigriceps*, there is a bone of very coracoidal appearance, and provided with the perforation. By way of complicating the matter still more, I shall show, presently, that among the Panchet fossils there are several specimens of a probably Dicynodont bone (fig. 5, Plate V. [Plate 15]) which has much more resemblance to a scapula than that under discussion.

However, the main point, at present, is that a large bone, found associated with the bones of large Dicynodonts in Africa, should have its exact miniature representative, of a size appropriate to the small Dicynodonts of India, in the present Collection.

5. *Dicynodont Humeri.*—I have described and figured the humerus of an African Dicynodont in the 'Quarterly Journal of the Geological Society' for 1859 (p. 657, pl. xxiii. fig. 3).

A number of fragments of exceedingly similar bones occurred among the Panchet fossils; but, at first, they appeared to differ from

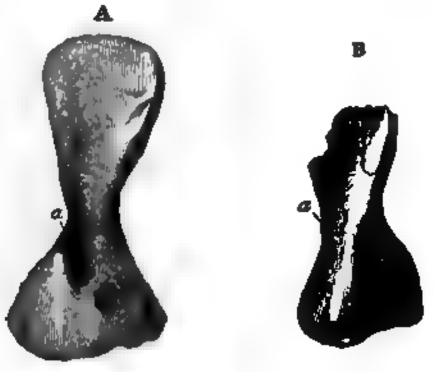


Fig. 3. Dicynodont Humeri: A, African; B, Indian. Reduced to one-half the natural size.

the African humerus by possessing a large, oval, supracondyloid foramen, or canal, traversing the bone immediately below its median constriction, in a direction from above and behind, downwards, forwards, and inwards; so that the upper end of the canal is situated on the hinder half of the inner face of the bone, while the lower end is on the inner half of the front face (*a*, Fig. 3 B).

On re-examining the humerus of the African Dicynodont, how-

ever, I found that it possessed a supracondyloid canal of quite the same character and dimensions, which had been concealed from view by the close similarity in colour, of the matrix with which the canal was filled, to that of the adjacent bone (*a*, Fig. 3 A).

In the accompanying woodcut (Fig. 3) the complete African humerus and the broken Indian one are represented, reduced to one-half the natural dimensions. In clearing away the very hard matrix from the African specimen, the bar of bone which bridged over the foramen was broken away, so that there is now only a groove in place of a hole.

A supracondyloid foramen occurs not unfrequently among Lacertian Reptiles, but not with the precise form and proportions which it presents in these two humeri.

6. *The roof of a Cranium.*—The only specimen of this portion of the skeleton of any animal, which I met with in the whole Collection, is that represented in Plate I. [Plate II] fig. I.

It is composed of portions of the two parietal and the supraoccipital bones, and of a third undivided bone wedged in anteriorly between the two parietals. The parietal bones are very thick (Plate I. [Plate II] fig. I *b*), and their posterior and external angles are produced into prolongations, which curve obliquely outwards and backwards, as in Lacertians generally. In the middle line, the parietals diverge to enclose the single median bone above mentioned, and to bound, with it, the large oval parietal foramen. Behind the foramen they unite in a median sagittal suture, so as almost entirely to cover the supraoccipital. Thus, with the median bone, they form very nearly the whole upper face of the fragment, but only the sides of its posterior face (which is directed almost at right angles to the upper face), the middle of the posterior face (fig. I, *c*) being due to the supraoccipital. The under face of the right postero-lateral prolongation of the parietal (the longer of the two) is flattened and rough, for union with the corresponding process of the exoccipital (or exoccipital and opisthotic): its front face shelves downwards and forwards, while its hinder and inner face is almost perpendicular; so that it is trihedral in section, and presents a curved upper edge, which is continued forwards into two ridges divided from one another by a shallow and narrow groove. The outer of these ridges separates the upper, from the lateral, face of the parietal. The lateral face (fig. I *b*) is, on the whole, concave from above downwards, as well as from side to side, but is divided by a strong, sharp, horizontal ridge into an upper and a lower division.

The anterior edge of the postero-lateral process is not continued into this ridge, but ends separately from it and a little below it (fig. 1 *b*).

On the under surface, the supraoccipital presents a median ridge, and extends much further forward than above; to within 0·2 inch, in fact, of the parietal foramen. The parietal and the median anterior bone are seen to be but slightly concave from side to side, so that the lateral view (fig. 1 *b*), gives, very nearly, the real thickness of the bones.

On comparing this fragment of the roof of a reptilian cranium with the corresponding region of the skull in the Dicynodonts, I find it longer and narrower, in proportion, than in *Dicynodon Murrayi*, but not longer than in *D. lacerticeps* and *D. tigriceps*, and not so long as in *Oudenodon*. The disposition of the lateral ridges of the parietal bones is very similar in *D. tigriceps*, though the African skulls, having been hewed out of a hard matrix, have their details far less distinctly preserved than the Indian fossils.

But the circumstance, which, more than any other, leads me to think that this cranial fragment appertains to *Dicynodon* is, that in one of the specimens of *Dicynodon Murrayi* (named *Ptychognathus declivis*, in the British Museum) and in *Dicynodon lacerticeps* (and perhaps in *Oudenodon Greyii*), while the two parietal bones are separated by a median suture, a single intercalary, or Wormian, bone is interposed between them and the frontals, and bounds the parietal foramen, in just the same way as the single median bone limits it in the Indian fossil.

This is so singular and unusual a conformation of the skull, that notwithstanding the imperfect condition of this fragment, and the want of any positive evidence that divided frontals existed in front of and distinct from the median bone, I feel justified (taking the rest of its structure into consideration) in regarding it as Dicynodont.

III. Remains of a Thecodont Saurian.

The fragment of a small jaw, containing two mutilated teeth, represented of three times the natural size in the accompanying woodcut (Fig. 4), is the only positive evidence of the existence of Sauria, other than Dicynodonts, which I have been able to meet with among the Panchet fossils.

The portion of the jaw is broken inferiorly and at each end. Its inner and outer walls are smooth, and not sculptured. The one wall, which I take to be the outer, is slightly higher than the other; between the two, two teeth are implanted. Of these teeth, the crown

of the anterior had been broken off and cemented to the base before the specimen reached me. The cement has allowed the crown to slip a little out of position; so that it is placed rather further back, and slopes more inwards than it should do (Fig. 4 A). I make this remark because the specimen is so delicate that I dare not venture to reset the tooth. The anterior tooth is entire except at its apex. On carefully scraping away the substance of the jaw behind the posterior tooth, I found it to be lodged, by a broad fang rather more than $\frac{1}{10}$th of an inch long, in a distinct alveolus (Fig. 4 B).

The tooth, when entire, must have been between 0·3 inch and 0·4 inch long; so that the fang constituted less than a third of its length. The fang and base of the crown of the tooth are rather more than 0·1

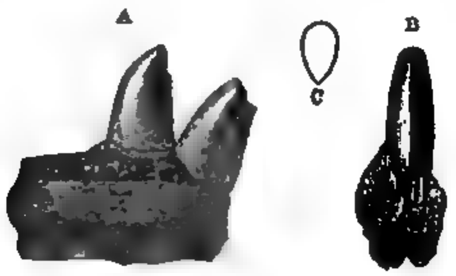


Fig. 4. A portion of the jaw of a Thecodont Saurian (*Ankistrodon*): magnified three times. A, side view. B, back view of one of the teeth. C, outline of the transverse section of one of the teeth.

inch long by 0·5 inch broad, and a section in these regions would therefore be an oval, elongated from before backwards.

In its basal half the crown is rounded behind, as in front; but in the apical half (Fig. 4 C), while it remains round anteriorly, its posterior surface gives rise to a sharp median crest, which is finely serrated, or, rather, marked by transverse grooves. The upper part of the tooth is suddenly recurved, so that the anterior superior contour of the tooth is very convex. The posterior contour is straight, so far as it exists; but the extreme apex of each tooth is broken away. The teeth exhibit faint longitudinal basal markings; and delicate raised striæ, running from the summits of the teeth downwards, parallel with the anterior and posterior contours, are particularly visible on the inner face of the anterior tooth.

From the hooked character of the teeth, I shall name this Saurian *Ankistrodon* (*ἄγκιστρον, ὀδούς*) *indicus*.

These teeth are very similar in their general characters to those of *Megalosaurus*; to those of *Teratosaurus* (von Meyer) from the Upper

Keuper near Stuttgart; to those of *Bathygnathus* (Leidy) from strata of Triassic, or Permian, age in Prince Edward's Island; to those of *Zanclodon crenatus* (Plieninger) from the Lettenkohl; and to those of *Cladyodon* (Owen) from the Warwickshire Trias. *Zanclodon* and *Cladyodon*, it is interesting to remark, are associated with Labyrinthodonts.

But the teeth of all these genera differ from those of *Ankistrodon* in being provided with an anterior as well as a posterior serrated ridge. In this respect the *Clepsysaurus* of Lea, from the Pennsylvanian Trias, which has curved teeth without any anterior ridge, comes nearer to the Indian Saurian.

Thecodontosaurus and *Palæosaurus*, on the other hand, have straight teeth with anterior and posterior serrated edges, and thus depart more widely from *Ankistrodon*.

Vertebræ, in a more or less broken state, are very numerous among the Panchet fossils. Most of them appear to belong to one genus and species, and from these I have been able to select an almost complete series, exemplifying the vertebral characters of each region of the body of the animal to which they belong.

I shall, in the first place, describe these vertebræ, and subsequently I shall inquire to what genus they may with most probability be referred.

IV. SAURIAN VERTEBRÆ.

1. *Cervical vertebra* (Plate I. [Plate 11] fig. 4).—The hinder part of the neural arch and the spinous process of this vertebra are wanting, but the rest of it is in good preservation. The centrum, or body, has at each end an articular face, presenting a spheroidal concavity, which may be called shallow, as its depth is not more than a fifth of the length of the vertebra. The general plane of each articular face is oblique to the axis of the centrum; so that the anterior face looks downwards, as well as forwards, and the posterior face upwards, as well as backwards. Viewed from below (fig. 4 *a*), the centrum is seen to be constricted in the middle of its length, and to present a sharp, though low, median crest, which is lower in the middle than at the two ends.

On the side of the centrum (fig. 4) is a curved ridge, concave downwards, which terminates in front upon a short broad process, truncated at its extremity, so as to offer an elongated oval facet, with which the tubercle of a rib articulated. Separated from this by a narrow groove, is a second similar facet, to which the head, or *capitulum*, of the rib was applied.

The anterior articular processes (or zygapophyses) alone are preserved; they are broad and flat, and look a little inwards as well as upwards.

No trace of the original sutural union of the neural arch with the centrum is visible in this vertebra.

The height of the neural arch is not equal to more than one-third of that of the articular face of the centrum (fig. 4 *b*).

2. *Cervical vertebra* (Plate I. [Plate 11] fig. 5).—In this vertebra the neural arch and its appended parts are almost wholly wanting. It differs from the preceding in the following respects:—It is somewhat more constricted and pinched in at the sides; and these shelve more continuously into the infero-median keel, which is uninterrupted. The lateral ridge is so abruptly arched as to be almost angulated; the fossa beneath it is much deeper, and the processes for the *tuberculum* and *capitulum* of the rib are much more prominent.

3. *Cervical vertebra* (Plate I. [Plate 11] fig. 6).—The neural arch and spine are almost entire, the posterior oblique articular processes (or post-zygapophyses) and the left anterior oblique articular process (or pre-zygapophysis) being also preserved. The centrum, longer and narrower in proportion than in the other vertebræ, is slightly concave at both ends,[1] and it is less constricted in the middle than either of the other two. The infero-median and the lateral ridges are very little marked, the latter being but slightly concave downwards; and the costal facets are small and but little prominent.

The spinous process is flattened from side to side, broad from before backwards, and cut square at its apex. Just above the level of the post-zygapophyses it presents an antero-posterior horizontal ridge on each side. The planes of the articular surfaces of the post-zygapophyses, which are flat and oval, are inclined at a little more than a right angle, and between the post-zygapophyses there is a deep fossa.

An oblique ridge runs downwards and forwards, towards the process for the tubercle of the rib, from the outer edge of the post-zygapophysis, upon the neural arch, and enlarges at its extremity as it dies out. The two costal processes are worn away at the ends, but they seem to have been relatively smaller than in the other vertebræ.

The length of the centrum of this vertebra is 0·95 inch; the vertical diameter of the posterior face of the centrum, 0·47 inch.

[1] When the figure was drawn, the matrix, which filled the anterior articular face of the vertebra, had not been removed.

4. *Cervical vertebra* (Plate II. [Plate 12] fig. 4).—So much of this vertebra as is preserved very much resembles that just described; but there is no horizontal ridge upon its neural spine, and its proportions are very different; for while its length is 1·1 inch, or only about a sixth greater than the preceding, the vertical diameter of the posterior articular face is 0·7 inch, or half as great again as in the foregoing vertebra.

Unless, therefore, there was some unusual inequality in the length of the cervical vertebræ of this reptile, I should be inclined to suspect that the vertebra represented in Plate II. [Plate 12] fig. 4 is derived from a different species from the others.

5. *Dorsal vertebra* (Plate II. [Plate 12] fig. 5).—The dorsal vertebra represented in Plate II. [Plate 12] fig. 5, has the centrum very much constricted in the middle, measuring only 0·4 inch transversely in this region, while the diameter of its anterior articular face is 0·75 inch, or nearly double. The under surface of the vertebra is not only devoid of any crest, but is almost flat from side to side; and the sides of the body of the vertebra are pinched in, so as to be concave from above downwards, as well as from before backwards. The margins of the posterior face of the centrum are broken away; and the fracture has so much encroached upon its articular surface, as only to allow one to see that it was, like the anterior, so slightly concave as to be almost flat. The articular faces of the centrum are perpendicular to its long axis. The sides of the neural arch are equal in height to the semidiameter of the anterior face of the centrum (fig. 5 *a*). The pre-zygapophyses have flat articular surfaces, which look slightly inwards as well as upwards, and they are separated by a notch. The ridges which bound their outer margins rise up upon the face of the spinous process, and bound a deep fossa in the base of the anterior face of that process (fig. 5 *a*). A similar fossa lies between the post-zygapophyses, the upper sides of which are produced into strong rounded ridges, which ascend upon the hinder edges of the spinous process. The latter is short and abruptly truncated at its upper extremity, which is slightly longer (fig. 5) and much thicker (fig. 5 *a*) than its root.

The transverse process of the vertebra consists of an almost vertical plate of bone (fig. 5), which extends directly outwards from the arch and body of the vertebra—its lowest point being situated close to the lower edge of the anterior articular facet, while its upper extremity is connected with the pre- and post-zygapophyses and with the neural arch. The upper part of the process thus forms a trihedral

pillar, the front edge of which curves upwards and forwards to the under surface of the pre-zygapophysis, while the posterior edge sweeps upwards and backwards, along the sides of the neural arch, to become continuous with the outer margin of the post-zygapophysis. A sort of shelf is thus formed between the latter and the transverse process. The lower edge is produced into a comparatively thin plate of bone, which passes into the upper surface of a short projection, proceeding from close to the lower margin of the anterior face of the centrum (fig. 5) and bearing an oval articular facet upon its truncated extremity. The distal end of the upper trihedral part of the process also presents the remains of an articular facet, the margins of which are broken away. This articulated with the tubercle, the lower facet with the head, of a rib. The trihedral part of the process, and the descending plate into which it is continued inferiorly, form the upper and front walls of a deep conical fossa, which is bounded internally by the neural arch, and posteriorly by a low vertical ridge upon that arch. No indication of a suture remains between the neural arch and the centrum.

6. *Dorsal vertebra* (Plate II. [Plate 12] fig. 6).—This belonged to a much larger animal than the foregoing, but its characters are very similar. The axis of the trihedral 'tubercular' costal process, however, is less inclined downwards, and the vertical plate into which its lower edge was continued when the bone was entire, does not directly pass into the 'capitular' costal process, which is little more than a facet of the side of the body of the vertebra, but is separated from it by an interval of 0·2 inch. The distal face of the tubercular process has the form of a triangle, with its base turned forwards and downwards. (See fig. 6, in which, however, the upper contour of the triangular surface is not quite sufficiently defined.) The conical fossa, corresponding to that described above, is very well developed, as is the ridge which bounds it behind (fig. 6 *b*). The posterior contour of the articular surface of the pre-zygapophysis is defined by a sharp, thin, raised line.

The planes of the articular surfaces of the centrum of this vertebra are slightly oblique to the axis, and their concavity is somewhat greater than in the foregoing specimen. The depth of each articular excavation, however, certainly does not exceed one-fifth of the length of the axis of the centrum.

7. *Dorsal vertebra* (Woodcut, Fig. 5).—In this vertebra, the anterior and posterior faces of the body, which is much constricted in the middle, are nearly flat. The lower edge of the vertically elongated

capitular facet (*cp*), broader below than above, and concave from above downwards, is nearly on a level with the centre of the anterior articular face of the body of the vertebra. The shelf-like ridge (*e*) which connects the transverse process with the post-zygapophysis, instead of descending in its course from behind forwards, as in the other vertebræ, ascends a little.

The conical fossa (*a*) is well defined, and its posterior boundary ends in the apex of a V-shaped ridge. The posterior leg of the V (*b'*) answers to the hinder part of the curved ridge seen on the

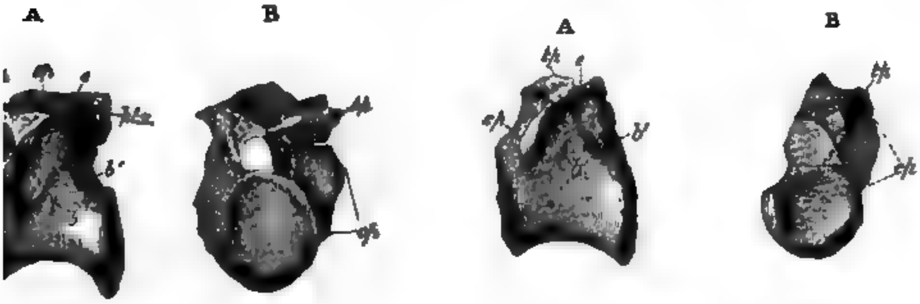


Fig. 5. A dorsal vertebra: of the natural size. Fig. 6. A dorsal vertebra: of the natural size, *sp*, spinous process. *pz*, pre-zygapophysis. *ptz*, post-zygapophysis. *tp*, transverse process bearing the tubercular facet. *cp*, capitular facet.

sides of the cervical vertebra. The anterior leg (*b*), much more strongly marked, is the continuation of the posterior boundary of the conical fossa.

8. *Dorsal vertebra* (Woodcut, Fig. 6).—This vertebra much resembles the preceding, but its middle ventral edge is slightly keeled, and the lower edge of the capitular facet is situated well above the level of the centrum of the vertebra, whence I conclude that it was placed further back in the dorsal series than any of the others. The ridge *b'* is but very slightly marked.

9. Of *Sacral vertebræ* the Collection has yielded only two specimens, both in a very fragmentary state.

Sacral vertebra (Plate II. [Plate 12] fig. 7).—The centrum of this vertebra is short, constricted, and flattened from side to side. The posterior articular face is flatter than the anterior, but exhibits no trace of having been anchylosed with the succeeding vertebra. The right sacral rib is present, and is constricted near the centrum, and expanded at the extremity (fig. 7), which presented a broad irregular surface to

the ilium (fig. 7 *b*). The spinous process is high, comparatively thin and narrow (fig. 7 *a*).

10. *Sacral vertebra* (Plate III. [Plate 13] fig. 1).—The present specimen is an anterior half of a sacral vertebra in a very good state of preservation. The posterior half of the centrum and the post-zygapophysis, however, are lost, the vertebra having broken through its middle, which was obviously much compressed and constricted (fig. 1 *b*).

The figures give, better than words could do, the characters of the spinous process, pre-zygapophyses, and centrum of this fragment. The sacral ribs are still only united suturally with the neural arch and the centrum, which is the more remarkable as, in the preceding specimen, no trace of this suture is discernible. As in the foregoing vertebra, the sacral ribs are constricted in the middle and expanded at the two ends, the outer being the larger. Each has a triangular transverse section, one face of the triangle looking backwards, another upwards and forwards, and the third forwards and downwards. The posterior face (fig. 1 *b*) exhibits a well-developed tubercle, with a flattened face close to its outer margin, and thus gives the broad outer end of the rib, which abutted on the ilium, an irregularly quadrate, instead of a triangular, form (fig. 1).

11. *Caudal vertebra* (Plate II. [Plate 12] fig. 8).—In the mutilated *caudal vertebra* represented in this figure, the transverse processes are given off just at the junction of the centrum and the neural arch, between which no trace of any suture remains. The spinous process is broken away; but the fractured surface whence it sprang is not more than a third as long as the neural arch, and lies close to the post-zygapophyses. The inferior surface of the centrum is not only flattened, but is longitudinally grooved in the middle. The edges of its articular faces are obliquely bevelled off, especially below. This bevelling is more marked on the lower half of the circumference of the posterior articular face than anywhere else, and here gives rise to two articular surfaces (fig. 8 *a*) for the subvertebral, or chevron bones.

12. The *Caudal vertebra* (Plate III. [Plate 13] fig. 2) is more complete and shows the relative size and proportions of the spinous process, which arises from a much greater proportional extent of the upper surface of the neural arch; so that it probably belonged to a more anterior region of the tail than the foregoing. Its body is flattened, but not grooved, below (fig. 2 *b*).

13. The *Caudal vertebra* (Plate III. [Plate 13] fig. 3) has suffered abrasion on the anterior and posterior surfaces of its centrum ; so that the articular concavity is reduced to its central portion in front (fig. 3 *a*), and has disappeared behind.

The succeeding figures (Plate III. [Plate 13] figs. 4, 5, 6, and 7), exhibit vertebræ from the posterior region of the tail, showing the usual elongation of the centrum, reduction of the processes, and more and more backward setting of the spinous process. The anterior and posterior faces of the centra are, in all these vertebræ, moderately concave, the appearance of convexity in the front face of fig. 6 resulting from the presence of a mass of adherent matrix.

It appears, from the facts which have been detailed, that the spinal column of the Saurian to which these vertebræ belonged, was composed of cervical, dorsal, sacral, and caudal, with or without lumbar, vertebræ, the centra of which were amphicœlous, but not very deeply excavated at either extremity ; and that the centra of the dorsal vertebræ presented a more marked median constriction than those of either the cervical or the caudal region. The neuro-central suture was absent in all the specimens observed. The spinous processes appear to have been well developed throughout, except, perhaps, in the extreme end of the tail. In the cervical region, the bodies of the vertebræ are longer in proportion, than in the back ; and their sides present short double costal processes, an upper 'tubercular' and a lower 'capitular' separated by a notch, for the tubercular and capitular parts of the ribs. In the anterior dorsal region the tubercular process ascends on to the side of the neural arch, while the capitular process remains on the lower half of the body ; at the same time, the tubercular process elongates and acquires a trihedral form, its lower edge becoming produced into a thin plate. In the middle, or posterior, dorsal region the capitular process becomes vertically elongated, and ascends on to the upper part of the body and even on to the neural arch. A sort of shelf extends from the root of the 'tubercular' transverse process backwards and forwards to the zygapophyses, the surfaces of which are flat and but little inclined.

The sacral vertebræ are distinguished by the stout, constricted, trihedral, sacral ribs, by which they are connected with the ilium.

The caudal vertebræ have short transverse processes and undivided spinous processes ; and some, at any rate, possessed subvertebral bones.

That the vertebræ now described are not Labyrinthodont may be regarded as certain ; not less clear is it, I think, that they belong to

that great group of Lacertilia with amphicœlous vertebræ (of which more than two enter into the composition of the sacrum) which contains the genera *Megalosaurus*, *Iguanodon*, *Platæosaurus*, *Protorosaurus*, *Dicynodon*, and very probably the other Thecodontosauria, *Rhynchosaurus* and *Hyperodapedon*. It is a group which ranges from the latest Palæozoic epoch (the Permian) to the latest Mesozoic (the Cretaceous), and some of the members of which are distinguished by dimensions which exceed those of all other known terrestrial animals.

Among these genera, cervical vertebræ have been observed in *Protorosaurus*; dorsal vertebræ in *Megalosaurus* and *Iguanodon*; sacral vertebræ in *Megalosaurus*, *Iguanodon*, *Platæosaurus*, *Protorosaurus*, and *Dicynodon*; caudal vertebræ in all these genera and in *Thecodontosaurus*, in such a state of preservation that their essential peculiarities can be readily made out.

If the cervical vertebræ of the Indian Saurian be compared with the figures and descriptions of those of *Protorosaurus*, given by Von Meyer in his "Saurier aus dem Kupferschiefer der Zechstein-Formation," the resemblance between the two will at once be seen to be most striking.

"In the cervical vertebræ of *Protorosaurus*, both articular faces were concave and slightly inclined forwards. In the vertebræ of this animal, generally, the neural arches and the bodies are not suturally separated. The spinous processes of the cervical vertebræ were remarkably broad from before backwards, and their articular surfaces also were large."

Von Meyer describes cervical ribs, broad at the proximal ends, but tapering off to fine filaments posteriorly; these, says he, "were attached to the anterior ends of the centra by means of a flat [transverse] process whence a distinct ridge passed backwards."

However, the cervical vertebræ represented in tab. I. fig. 1 of the work cited appear, like those of the Indian fossil, to have *two* short anterior transverse processes; and in the sixth cervical there is, as in the vertebra represented in Plate II. [Plate 12] fig. 4, an oblique ridge running from the side of the centrum on to the postzygapophysis.

Again, the fact that the cervical vertebræ of *Protorosaurus* are longer than the dorsal ones is particularly noted by Von Meyer.

The details of the structure of the dorsal vertebræ of *Protorosaurus* have not yet been satisfactorily made out; but, in *Iguanodon*, the capitular costal process of the dorsal vertebræ becomes vertically elongated in the same way, the root of the tubercular costal process takes the same sort of trihedral form, and spreads out before and

behind, so as to give rise (as Professor Owen has already particularly pointed out) to a kind of platform connecting the pre- and post-zygapophyses. Furthermore, there is an oblique ridge which ascends from the back part of the body of the vertebra forwards, upwards, and outwards to the root of the tubercular process; and in front of, and behind, this there is a fossa; though the proportions of these ridges and fossæ are very different from those observed in the vertebræ under description.

The form of the bodies and of the ribs of the sacral vertebræ gives them more resemblance to those of *Dicynodon* than to those of any of the genera enumerated.

The anterior caudal vertebræ are very like those of *Protorosaurus* and of the Thecodont saurians generally; but the posterior caudal vertebræ do not exhibit any indication of those bifurcated neural spines which appear to be characteristic of these vertebræ in *Protorosaurus*.

That the series of vertebræ, then, appertained to some Lacertilian of the group above defined I have no doubt, but it is a very difficult matter to decide whether they belong to *Dicynodon*, or to some other genus of Saurian. The arguments by which one's decision must be influenced appear to be the following:—

1. All the Reptilian teeth found among the Panchet fossils, and all the fragments of jaws (save the one specimen of *Ankistrodon*), certainly belong to *Dicynodon*.

2. The vertebræ of the series described vary much in size; and while the largest would answer very well to the largest Dicynodont cranial and dental remains, the smallest correspond with the smallest teeth and mandibles.

3. There are remains of humeri, besides coracoids, or scapulæ, as numerous in proportion as the vertebræ, which cannot be distinguished by any important character from those of the African Dicynodonts.

4. The sacral vertebræ are more like those of *Dicynodon*, than they are like those of any known Thecodont, or Dinosaurian, reptile; and so far as they can be compared, the dorsal vertebræ are like those of the African Dicynodonts,[1] except that the articular faces of the centra are far less deeply concave.

On the other side it may be said—

1. That, as will be seen below (p. 21), there is reason to believe that a fragmentary vertebra of large size (Plate IV. [Plate 14], figs. 2, *2a*, *2b*) belongs neither to *Dicynodon* nor to *Ankistrodon*: whence

[1] The imperfect dorsal vertebra of *D. tigriceps*, described by Professor Owen, and now in the British Museum, is the only one I have been able to examine.

the possibility that the vertebræ belong to some Saurian, the teeth of which are not in the Collection, must not be left out of sight.

2. That the humerus, in some existing Lacertilians, presents very nearly the same characters as that of *Dicynodon*; and that, in general form, at any rate, the humerus of *Protorosaurus* closely resembles it.

The latter arguments, however, do not appear to me to be nearly so weighty as the former, and I shall therefore assume that the vertebræ described appertain to *Dicynodon orientalis*.

Hitherto our knowledge of the free vertebræ of the Dicynodonts has been confined to an incomplete dorsal vertebra of *D. tigriceps*, described by Professor Owen in the memoir above mentioned.

The structure of an imperfect sacrum of *Dicynodon Murrayi* was described by myself in 1859.[1]

In 1862 Professor Owen gave an account of a complete pelvis of another Dicynodont in a paper "On the Dicynodont Reptilia," published in the 'Philosophical Transactions' for that year, in which the results attained are summed up as follows (p. 464):—

"From the study of the above-described most interesting portion of the Dicynodont skeleton we learn—

"1st. That there were no lumbar vertebræ, *i.e.*, none bearing the technical anatomical characters of such[2]; but that free ribs continued to be developed to the pelvic or sacral series.

"2nd. That the sacral series includes six vertebræ.

"3rd. That the ilium, ischium, and pubis coalesce into an 'os innominatum.'

"4th. That the juncture of the ossa innominata with the vertebral column is effected in two ways—by an overlapping or squamous syndesmosis and by the usual abutments; thus the anterior bony wall or surface of the pelvis, analogous to that formed by the expansion of the iliac bones in mammals, is here formed by the expanded ribs of the first sacral vertebra.

"5th. That the ischium of the right side joins that of the left, and the right pubis joins the left pubis; and that both pairs of pelvic hæmapophyses are coextended and confluent, not only along a continuous ischiopubic symphysis, as in mammals, but so as to obliterate

[1] "On some Amphibian and Reptilian Remains from South Africa." Quarterly Journal of the Geological Society, 1859, p. 642.

[2] "This negative character is open to the same kind of objection as that relative to the 'hippocampus minor' in animals below Man." [This note, I need hardly point out to any anatomist, contains a statement which is contrary to fact.]

the intervening vacuities, called '*foramina ovalia* seu *obturatoria*,' thereby repeating the character of the connate abdominal hæmapophyses in the Chelonian plastron."

In order to render our knowledge of the vertebral system of the Dicynodonts tolerably complete, we still need to be acquainted with the atlas and the odontoid vertebra, neither of which have been found among the Indian fossils.

The museum of the Geological Society, however, contains a beautiful specimen of the odontoid vertebra of a large African *Dicynodon*, which I have had figured (Plate IV. [Plate 14] fig. 1), of one-half the natural measurement—partly on account of the general interest which attaches to it, partly in the hope that so characteristic a bone may yet be discovered by collectors of fossils in India.

The vertebra is almost entire, the upper part of its spinous process, with the inferior and posterior parts of its body, being the only important parts which are deficient.

The front face of the centrum (Plate IV. [Plate 14] fig. 1 *b*) exhibits a huge odontoid process, the transverse contour of which is almost semicircular (fig. 1 *a*); while, viewed sideways (fig. 1), it has the outline of a triangle obliquely truncated at the apex. The process presents a triradiate articular surface, of which one limb descends in the middle line (fig. 1 *b*), and the others extend almost horizontally to the right and left (figs. 1, 1 *b*). The first of these surfaces is a little concave from above downwards and stops, below, at the upper margin of a broad semilunar surface (fig. 1 *b*) which forms the lower half of the front face of the body of the vertebra.

The upper surface of the odontoid process presents a deep notch filled with matrix, the floor of which passes into that of the neural canal of the vertebra.

The upper half of the posterior face of the vertebra exhibits a corresponding proportion of a deep articular cavity (Plate IV. [Plate 14] fig. 1 *c*); but the lower half has been broken away as far as the middle of the vertebra, so that nothing can be made out respecting the form of the lower half of the articular cup, or its boundaries.

The odontoid, or atlantoidean, element (*i.e.*, the odontoid process and parts answering to the os odontoideum of Crocodiles) is not separated by any suture from the rest of the body of the vertebra—the lines which might be taken for such in the figures being merely the result of fracture.

Two short and very strong transverse processes pass from the sides of the body outwards and a little backwards. The pre-zygapophyses

are small, with flattened articular surfaces, and placed lower than the post-zygapophyses, which are much larger, and have transversely concave articular surfaces (fig. 1 *c*). The spinous process is exceedingly thick behind (fig. 1 *c*), and its posterior edge is almost vertical. Posteriorly, its upper edge is broken away; but, anteriorly, it is preserved, and its direction leads to the supposition that it sloped from in front and below, obliquely upwards and backwards. The anterior part of the spinous process is produced into a triangular projection which overhangs the odontoid process.

The odontoid vertebra just described much resembles that of existing Monitors.

Of the atlas vertebra I have seen no such perfect specimen; but a fine example of the skull, with the three anterior cervical vertebræ, of *Dicynodon tigriceps*, in the museum of the Geological Society, exhibits the atlas, though unfortunately in a very ill-defined condition. It is sufficiently obvious, however, that the ring-like bone was provided with a short, stout, descending process in the middle line below; and that it had two similar lateral processes, one on each side. It also appears that the portion of the body of the axis vertebra, wanting in the specimen described above, was keeled in the middle line below; and, antero-laterally, presented, on each side, an obtuse tubercle, which seems to answer to the capitular process of the other cervical vertebræ. It is interesting to observe that the third cervical vertebra of this specimen also presents an upper, large, tubercular process, arising, partly, from the neural arch, and, partly, from the upper part of the body, and a lower, small, capitular process. With these, the large tubercular and small capitular portions of the upper end of a rib remain connected.

V. A Saurian (not Dicynodont?) Vertebra.

The large, but much mutilated, vertebra, represented of the natural size in Plate IV. [Plate 14] figs. 2, 2 *a*, 2 *b*, appears to belong to the sacral region of some saurian reptile. The neural arch and spine, the post-zygapophyses, and both ends of the body of the vertebra are broken away. The pre-zygapophyses have much the same shape and inclination as those of the sacral vertebræ of the ***Dicynodon***; and their articular surfaces present a very distinct series of concentric markings, which may be seen, though they are less obvious, in the Dicynodont vertebræ. The surfaces for the attachment of the sacral ribs have much the same shape and relative proportions as in *Dicynodon*; but the under view (fig. 2 *b*) shows that the centrum was far less constricted in the middle (compare Plate II. [Plate 12]

fig. 7 *b*), more flattened, and, furthermore, covered with rugosities, which are absent in *Dicynodon*.

For these reasons I hesitate to refer this vertebra to that genus. Judging from Von Meyer's figure of the sacrum of *Protorosaurus*, it might belong to some large Thecodont of the ordinary type.

VI. LABYRINTHODONT (?) VERTEBRÆ. (Plate VI. [Plate 16], figs. 9, 10, 11.)

The discoidal bones, represented of the natural size in these figures, are deeply biconcave, and present, upon one edge, impressions which seem to indicate the attachment of neural arches. That represented in fig. 11 is much thicker in proportion than the rest, and its terminal cavities are narrower and more conical.

There are numerous vertebræ of this kind, some of the discoidal and some of the long type, in the Collection. The largest of the discoidal type has a vertical diameter of 0·95 inch by 0·55 inch in antero-posterior extent. The conical terminal articular cavities are at least 0·25 inch deep in the centre. Between the tumid margins the body is slightly constricted and smooth.

The largest of the long type has the same vertical measurement, but is nearly 0·8 inch long. It has a similarly slightly constricted and smooth body; and its articular cavities are deeper than in the former, so that their centres approximate equally closely. On the upper side of the body are two fossæ for the attachment of the neural arch, separated by an elongated surface, which formed the floor of the neural canal.

The more discoidal vertebræ present a curiously ichthyosaurian aspect, except that they, like the others, lack the lateral articular tubercles of that genus. The elongated vertebræ, on the other hand, somewhat remind one of the centra of the dorsal vertebræ of *Nothosaurus*, which become readily detached from their neural arches. But, in the first place, they differ in the deep conical concavities of their faces; and, secondly, if they really belonged to animals allied to *Nothosaurus*, some would, almost certainly, have been found with rudimentary transverse processes, or parts of these. They might be fish-vertebræ, but no piscine remains have presented themselves in the Collection. On the whole, I am disposed to refer them to the Labyrinthodonts; and, indeed, as vertebræ of the discoidal and long types are found of precisely similar vertical and transverse dimensions, the suggestion arises, may they not have appertained, respectively, to the two genera *Gonioglyptus* and *Pachygonia*?

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VII. SAURIAN SCAPULÆ (?). (Plate V. [Plate 15], figs. 4 and 5.)

I am inclined to regard the bones here figured as scapulæ, fig. 4 representing a bone of the left, and fig. 5 one of the right side. Each of these bones is very imperfect, the glenoidal articular surface being worn flat, and the edges and processes more or less broken. By combining the two, however, a tolerably complete notion of the form of the bone may be obtained.

This 'scapula' is flattened from side to side superiorly, thick and rounded at its lower end (fig. 5 *c*), the two portions being connected by a narrow trihedral neck, above which the bone expands considerably (fig. 4). The anterior edge above the neck (fig. 5 *b*) is thin; the posterior (fig. 5 *a*) thick and rounded; the inner surface (fig. 5) is concave from above downwards; the outer (fig. 4) convex in the same direction, but somewhat concave from side to side. Close to the posterior margin and about a third of an inch above the glenoidal face, the outer surface presents a tuberosity (figs. 4 and 5 *a*). From the inner surface of the neck a thin process arises, which is directed forwards and a little inwards, and ends in a rough broken facet, continuous with the glenoidal surface (figs. 5 and 5 *b*). The angle which this process makes with the plane of the expanded part of the bone is shown in fig. 5 *c*. These bones are either scapulæ or ilia. But they are unlike the ilia of *Dicynodon*; and I should have considered them to be the scapulæ of that animal, except for the difficulties discussed above, when the bones represented in Plate V. [Plate 15] fig. 1 were considered. They have no sort of resemblance to the ischio-pubic bones of *Dicynodon*, and they are unlike any form of Saurian coracoid, or clavicle, with which I am acquainted.

Given, two new genera of Labyrinthodonts; a Dicynodont, new as a species, possibly of distinct generic or subgeneric type; and two teeth, imbedded in a fragment of jaw, of a Thecodont saurian, the precise affinities of which are unknown: to find the age[1] of the beds in which these remains occur.

Such is a statement of the palæontological problem which rises out of the preceding determinations, and the approximate solution of which must be based, not upon unknown possibilities of distribution in time, but upon what is at present known with regard to the occurrence of allied genera.

[1] I use the word age in the sense of 'Homotaxis'; for an explanation of which term see the Anniversary Address to the Geological Society for 1862.

Lacertilian reptiles, with, generally, serrated teeth, implanted in distinct alveoli, are known, at present, to occur in the newer (*Megalosaurus*) and older (*Thecodontosaurus*, *Palæosaurus*, *Cladyodon*, &c.) Mesozoic rocks, and in the Permian formation (*Protorosaurus*). Were one's knowledge of *Ankistrodon*, then, less fragmentary and imperfect than it is, no safe argument could be based upon its occurrence.

Nor will the *Dicynodon* help much ; for the age of the African Dicynodonts has yet to be accurately determined. At present, I think, there is no evidence to decide whether they are older Mesozoic or newer Palæozoic.

A single Labyrinthodont, *Micropholis Stowei*,[1] has been discovered in association with the African Dicynodonts. It is more like the *Brachyops* of Mangali than any of the Panchet fossils ; but it is not sufficiently similar to any form of Labyrinthodont, which occurs in rocks of known age, to help us to a conclusion in the present matter ; though the fact that Dicynodonts are associated with Labyrinthodonts in Eastern Asia, as in Southern Africa, in itself demonstrates an interesting analogy between the only reptiliferous formations of the two regions, which are, at present, known.

The genera *Galesaurus* (Owen) with its Simosaurian and Nothosaurian analogies, and the Crocodilian *Cynochampsa* (Owen), found in association with Dicynodonts, may be thought to incline the balance in favour of the Triassic age of the Karoo beds, just as does the analogy of *Dicynodon* and *Oudenodon* with *Rynchosaurus*. But such analogies cannot be regarded as decisive, especially when we recollect that the Permian *Rhopalodon* has canines as remarkably developed as those of *Galesaurus*.

The Labyrinthodont evidence remains. The distribution of the European Labyrinthodonts, at present known, is as follows :—

LOWER OOLITE OR LIAS.—One genus : *Rhinosaurus*. Judging from M. Fischer de Waldheim's figures and description,[2] this is certainly a Labyrinthodont.

TRIAS.—Six genera : *Mastodonsaurus*, *Labyrinthodon*, *Metopias*, *Capitosaurus*, *Trematosaurus*, *Xestorrhytias*.

PERMIAN.—Three genera : *Dasyceps*, *Zygosaurus*, *Melosaurus*.

CARBONIFEROUS.—Six genera : *Archegosaurus*, *Sclerocephalus*, *Parabatrachus*, *Anthracosaurus*, *Loxomma*, *Pholidogaster*.

To this series of Carboniferous Labyrinthodonts the American

[1] See the Quarterly Journal of the Geological Society for 1859, p. 642.

[2] " Notice sur quelques Sauriens del' Oolithe du Gouvernement de Simbirsk, par G. Fischer de Waldheim." Bulletin de la Société Impériale des Naturalistes de Moscou, tom xx. 1847, I. 362.

genera *Baphetes*, and *Raniceps* must be added ; and possibly, though not certainly, *Dendrerpeton*, *Hylonomus*, and *Hylerpeton*. Looking at this list of genera, I do not think that it is permissible to affirm that the Labyrinthodonts are either characteristically older Mesozoic, or newer Palæozoic—nature seeming to have spread them, with great impartiality, throughout the Triassic, Permian, and Carboniferous rocks, as far down as the horizon of the English Carboniferous limestone.[1]

Nor does our present information enable us to say that any particular type of structure, among these animals, is to be met with in only one of the three great formations in which they occur.

The *Mastodonsaurus* of the Trias has well-ossified vertebræ ; but so has the *Anthracosaurus* of the Scotch equivalent of the Coal-measures.

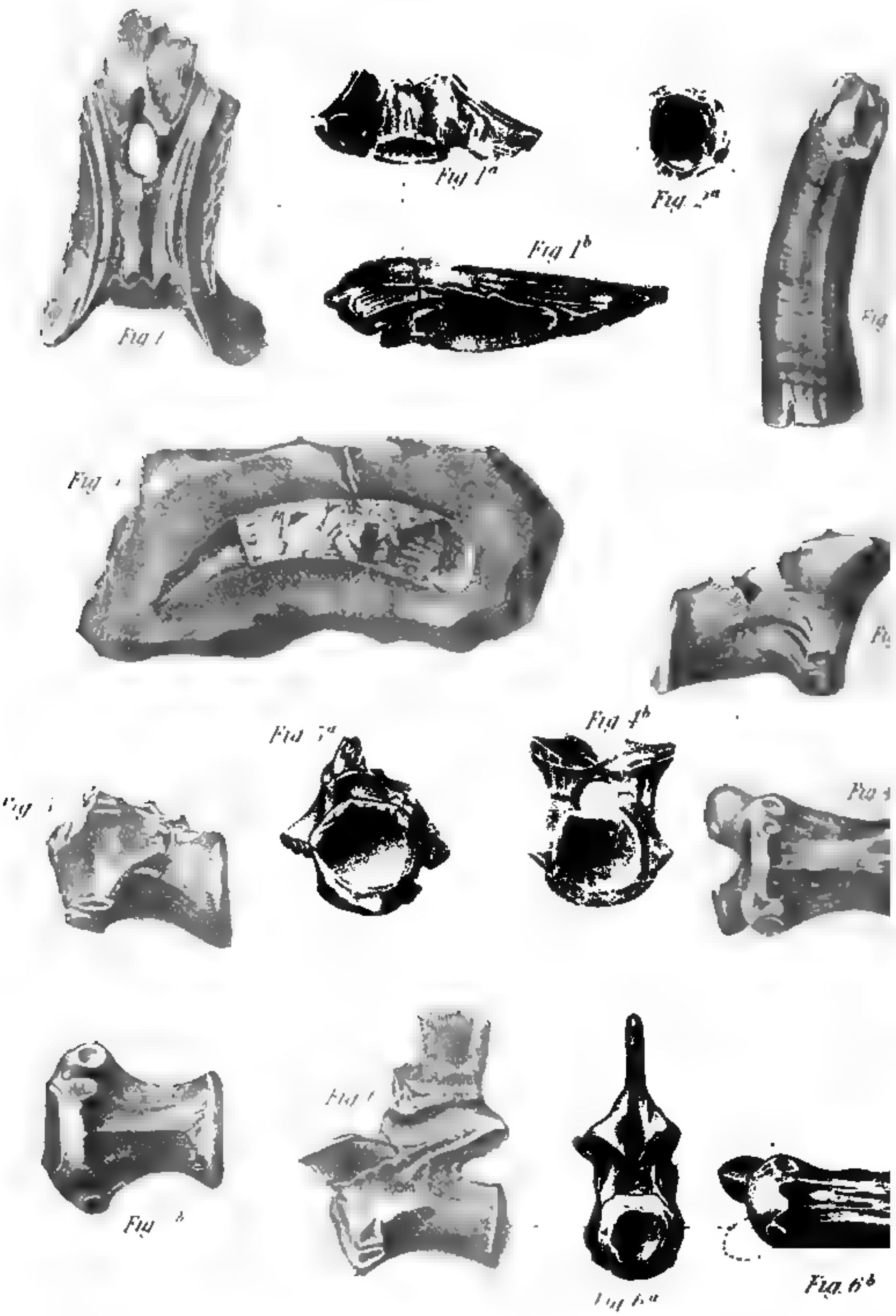
The Archegosauria of the Carboniferous epoch, on the other hand, have for the most part very imperfectly ossified vertebræ ; but then we know absolutely nothing of the structure of the spinal column of any Mesozoic, or Permian, Labyrinthodont, except *Mastodonsaurus* ; and in addition, the very fish-like *Pholidogaster* has well ossified vertebræ. Long-headed and obtuse-headed Labyrinthodonts occur in each formation. In fact, the Labyrinthodonts, as a group, as effectually bridge over the gap between the Palæozoic and Mesozoic formations, as Teleostean fishes and the Crocodilia bridge over that between the Mesozoic and Cainozoic series ; and just as the discovery of skulls of new genera of Percoid fishes, or of Crocodilia, would leave the question of the Mesozoic, or Cainozoic, age of the beds in which they occurred open, so, in my judgment, does the occurrence of Labyrinthodont crania in the upper beds of the Ranigunj coal-field leave the question of their Mesozoic, or Palæozoic, age undecided. So far as an accumulation of uncertainties may go towards forming a conviction, however, I should incline, in view of the whole vertebrate evidence (to which I confine myself), to the opinion that the Indian fossils are either of Triassic age, or belong to that fauna which will one day be discovered to fill up the apparent break between the Palæozoic and Mesozoic forms of life.

[1] See a "Description of *Anthracosaurus Russelli*," in the Quarterly Journal of the Geological Society for 1863, p. 56, *note*.

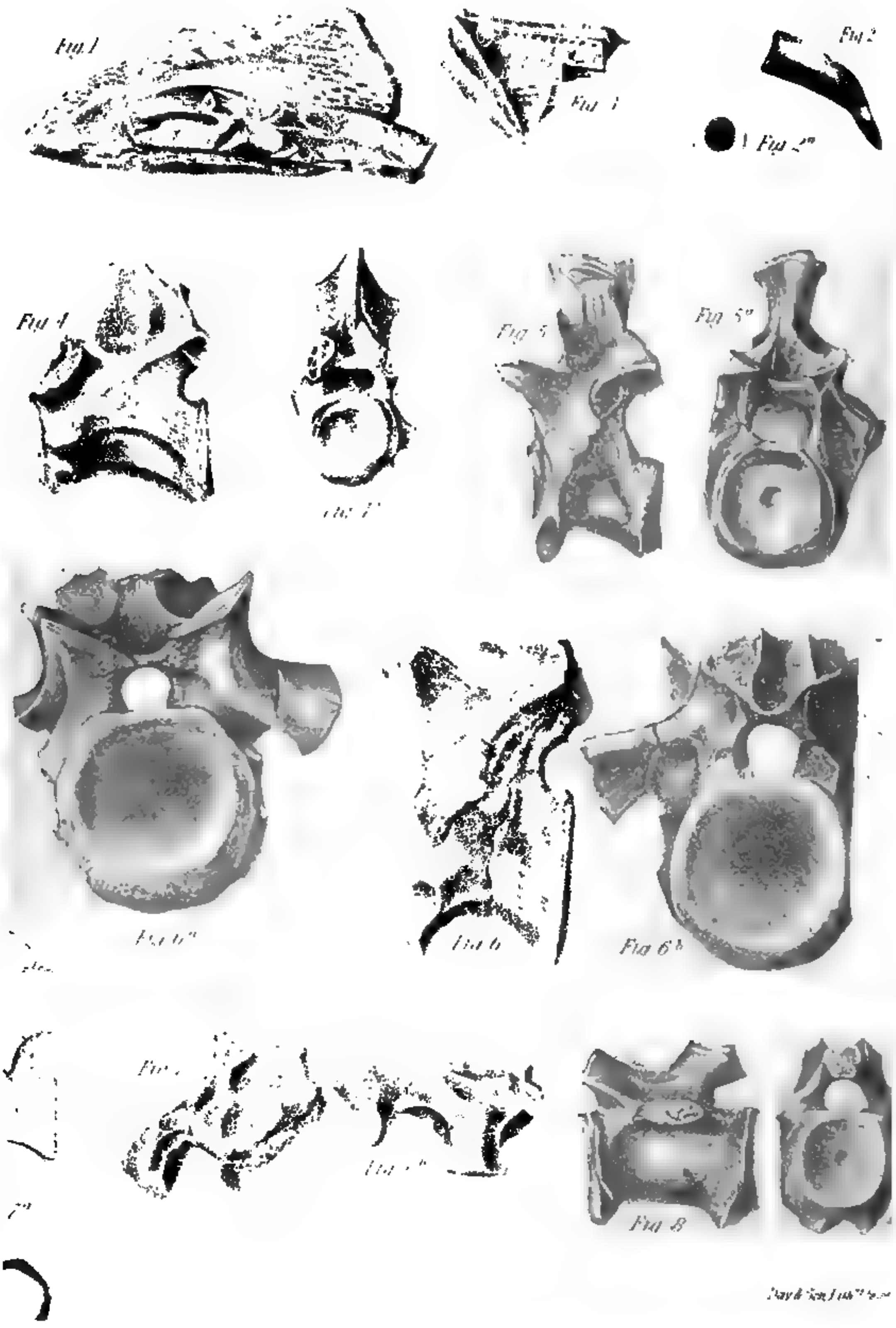
Surv of India

PLATE II

PANCHET ROCKS.

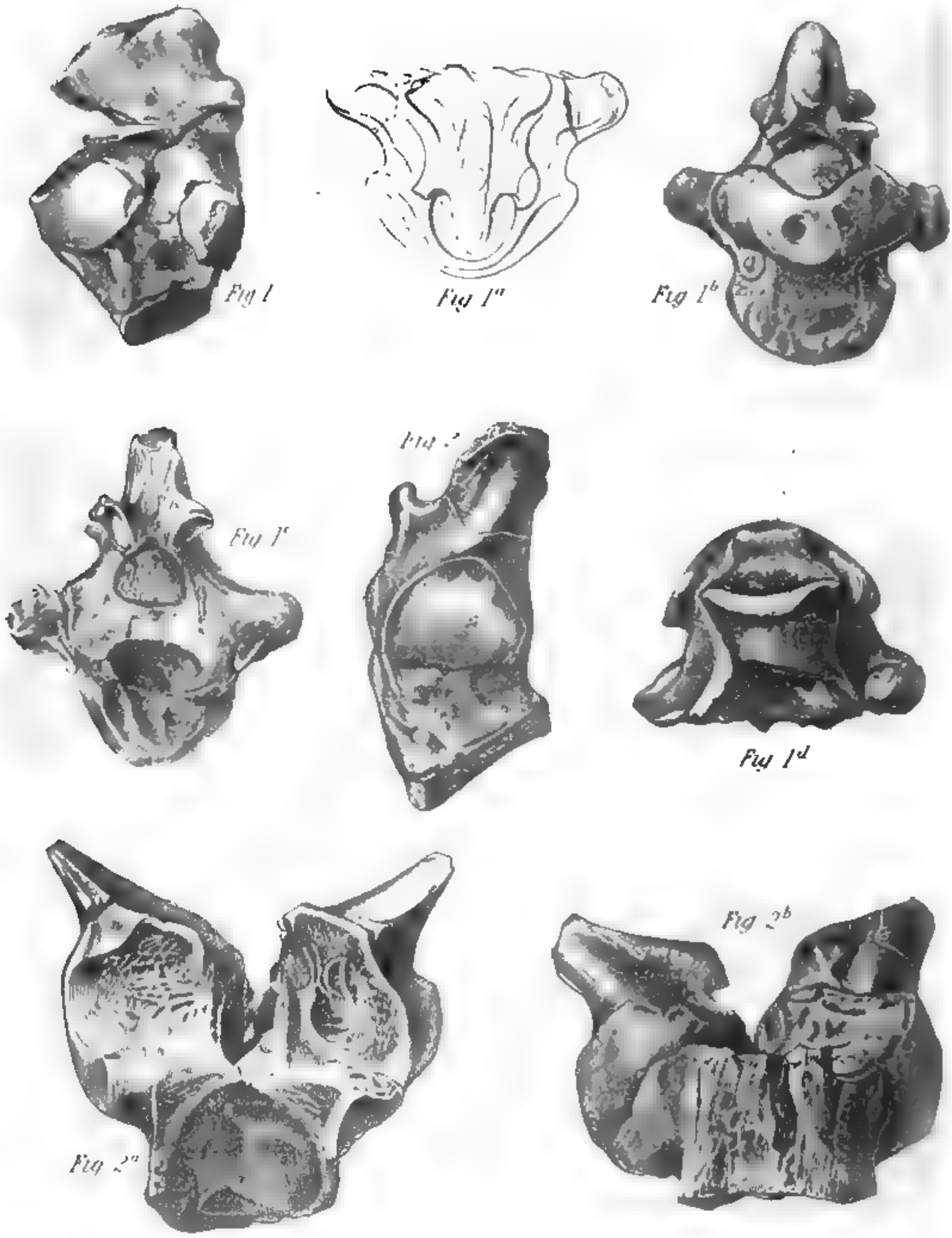


PANCHET ROCKS



eol: Surv. of India

PANCHET ROCKS



Day & Son, Lithrs

PLATE I. [PLATE 11.]

*** Unless the contrary be stated, the figures are of the size of nature.

Fig. 1. The roof of the cranium of DICYNODON ORIENTALIS, viewed from above ; *a*, from behind ; *b*, from the right side.

Fig. 2. A tusk of DICYNODON ORIENTALIS ; *a*, its transverse section.

Fig. 3. The exserted portion of a tusk of DICYNODON ORIENTALIS.

Fig. 4. The body, with the pre-zygapophyses, of a cervical vertebra, probably belonging to DICYNODON ORIENTALIS, viewed from the right side ; *a*, from below ; *b*, anterior view.

Fig. 5. The body of a cervical vertebra of the same species of Reptile, viewed from the left side ; *b*, from below ; *a*, anterior view.

Fig. 6. A nearly perfect cervical vertebra of the same species, viewed from the left side ; *a*, from behind ; *b*, from below.

PLATE II. [PLATE 12.]

*** Unless the contrary be stated, the figures are of the size of nature.

Fig. 1. Part of the right maxilla of DICYNODON ORIENTALIS, with a broken tusk in place.

Fig. 2. The end of a tusk of DICYNODON ORIENTALIS ; *a*, the same in transverse section.

Fig. 3. The symphysial end of the left ramus of the mandible of DICYNODON ORIENTALIS.

Fig. 4. An imperfect posterior cervical vertebra, viewed from the left side ; *a*, anterior view.

Fig. 5. An anterior dorsal vertebra, viewed from the left side ; *a*, anterior view.

Fig. 6. An anterior dorsal vertebra, wanting the neural spine and post-zygapophyses, viewed from the left side ; *a*, anterior view ; *b*, posterior view.

Fig. 7. An imperfect sacral vertebra, front view ; *b*, under view ; *a*, side view in outline, the detached spinous process being fitted on.

Fig. 8. An imperfect anterior caudal vertebra, viewed from the left side ; *a*, posterior view.

PLATE III. [PLATE 13.]

*** Unless the contrary be stated, the figures are of the size of nature.

Fig. 1. A view, from the left side, of a sacral vertebra of DICYNODON ORIENTALIS, of which the posterior half is broken away ; *a*, anterior view ; *b*, posterior view.

Fig. 2. A nearly complete anterior caudal vertebra, viewed from the right side ; *a*, anterior view ; *b*, viewed from below.

Fig. 3. An imperfect caudal vertebra, viewed from the left side ; *a*, anterior view.

Fig. 4. An imperfect caudal vertebra, from the left side ; *a*, front view ; *b*, inferior view.

Fig. 5. An imperfect posterior caudal vertebra, from the left side ; *a*, front view ; *b*, inferior view.

Fig. 6. A nearly complete posterior caudal vertebra, from the left side ; *a*, from behind.

Fig. 7. A posterior caudal vertebra—*a*, viewed from the left side ; *b*, anterior view ; *c*, inferior view.

PLATE IV. [PLATE 14.]

*** Unless the contrary be stated, the figures are of the size of nature.

Fig. 1. The odontoid vertebra of a large African DICYNODON, viewed from the left side, reduced to one-half the natural measurements ; *a*, from above ; *b*, anterior view ; *c*, posterior view.

Fig. 2. A fragmentary sacral vertebra of a Saurian Reptile, viewed from the left side ; *a*, from behind ; *b*, inferior view.

PLATE V. [PLATE 15.]

*** Unless the contrary be stated, the figures are of the size of nature.

Fig. 1. Bone of the shoulder-girdle, coracoid, or scapula, of DICYNODON ORIENTALIS.
Fig. 1 *a*. A fragment of another similar bone, from the opposite side.
Fig. 2. The glenoidal cavity of a larger bone of the same kind.
Fig. 3. The opposite face to that presented in fig. 1, of a smaller bone of the same kind.
Figs. 4 & 5. Reptilian scapulæ.

PLATE VI. [PLATE 16.]

*** Unless the contrary be stated, the figures are of the size of nature.

Fig. 1. The fragment of the skull of GONIOGLYPTUS LONGIROSTRIS, viewed from above; *a*, from below; *b*, from the left side; *c*, from the right side.

Fig. 2. Imperfect left ramus of a mandible, probably belonging to GONIOGLYPTUS LONGIROSTRIS, viewed from without; *a*, from within; *b*, from above.

Fig. 3. Represents a very imperfect fragment of the dentary portion of a Labyrinthodont jaw, from near the symphysis, which may have belonged to GONIOGLYPTUS.

Figs. 4, 5, 7. Fragments of Labyrinthodont jaws with anchylosed teeth like those of GONIOGLYPTUS.

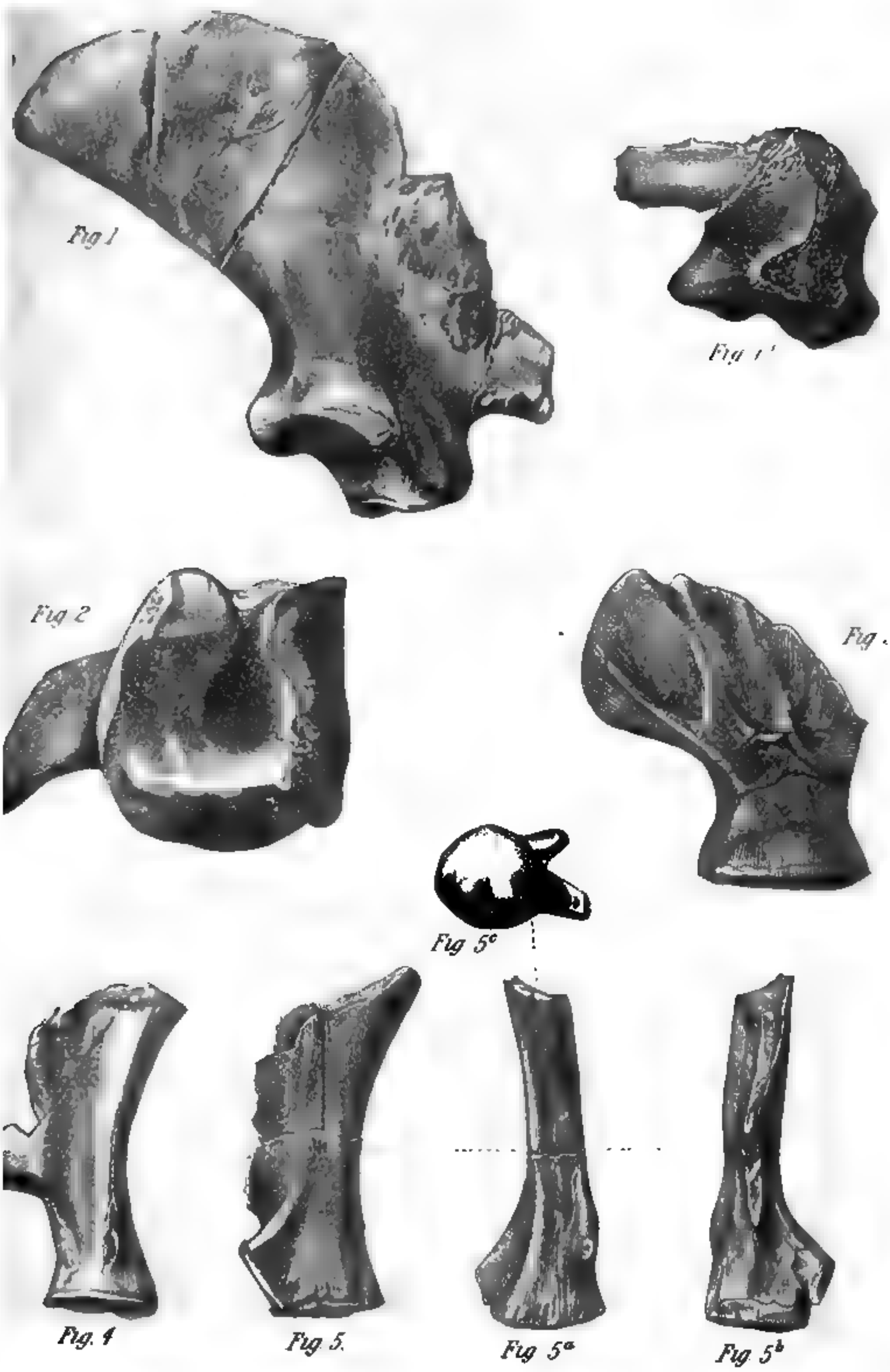
Fig. 6. A fragment of a jaw, probably Labyrinthodont, with broader and more conical teeth.

Fig. 8. A right lateral pectoral plate, probably belonging to GONIOGLYPTUS, viewed from below; *a*, from the outer side.

Figs. 9 & 10. Labyrinthodont (?) vertebræ of the discoidal type, face views; 9 *a*, 10 *a*, side views.

Fig. 11. A small Labyrinthodont (?) vertebra of the elongated type, face view; *a*, side view.

PANCHET ROCKS



Day & Son, L.t

PLATE IV

Pl. V

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PANCHET ROCKS

Day & Son

VI

ON THE METHODS AND RESULTS OF ETHNOLOGY.

Proceedings of the Royal Institution of Great Britain, vol. iv. 1862–66, *pp.* 461–463. (*Friday, June* 2, 1865.)

THE lecturer commenced by defining the nature and the limits of Ethnology. Biology being the name applied to the science of life and living things, Zoology is that division of Biology which deals especially with animals; and Anthropology is that branch of Zoology which is specially concerned with man. Ethnology is the more special science which determines the distinctive characters of the persistent modifications of mankind, ascertains the distribution of these modifications in present and past times, and searches after the causes or conditions of existence, both of the modifications and of their distribution.

Turning to a map of the world, the lecturer next indicated and briefly characterized, in successive order, the more obvious and prominent persistent modifications of mankind, commencing with the *Australians*. With dark skins, these people conjoin wavy hair; their skulls are always long, but are sometimes high and sometimes depressed. The antero-posterior and transverse diameters of the brim of the pelvis in the male are more nearly equal than is usually the case in Europeans.

The *Negritos*, inhabiting the belt of islands which lie between Australia, Polynesia, and Micronesia, have dark skins and woolly hair, the skull sometimes inclining towards the Australian, and sometimes towards the Polynesian type.

The *Amphinesians* have the colour of the skin brown, in lighter or darker shades, and the hair is long, black, and straight or wavy; the skull varies in character. These people cover an enormous area, occupying almost all the other islands of the Pacific and Indian oceans.

The *Americans* have black straight hair; the skin exhibits various

shades of reddish- and yellowish-brown, sometimes inclining to olive; the face is broad and scantily bearded, the skull broad and high.

The *Esquimaux* have also straight black hair and broad faces, with prominent cheek bones, but their skulls are remarkably long. They inhabit the Arctic shores of America and of Eastern Asia. The rest of Eastern Asia is peopled by the *Mongolians*, with skins varying in colour from yellow to olive, broad faces with flat noses, obliquely set small eyes, and straight black hair; the skull is never long, and usually is remarkably broad and rounded. The Lapps of North-eastern Europe have strongly-marked Mongolian characters, but the immense interval between the western limit of the Eastern Mongolians and Lapland is, in great measure, occupied by people with pale complexions, blue or light eyes, yellow or red hair, and prominent noses. These may be termed the *Xanthochroi*. They exhibit two very distinct forms of cranium—the Scandinavians having long heads, the Slavonians, Fins, South Germans, and Swiss, broad heads.

The *Melanochroi* have, like the Xanthochroi, prominent noses, pale skins, wavy hair, and abundant beards, but the hair is black or dark, and the eyes usually so. They inhabit Southern and Western Europe, Northern Africa, and Western Asia.

The *Negroes* with dark skin, woolly hair, projecting jaws, thick lips, and elongated skulls, people Central Africa; while the *Bushmen*, differing from the true negroes in their yellowish-brown colour, tufted hair, very small stature, and tendency to fatty and other integumentary outgrowths, inhabit the southern extremity of that continent.

The so-called "Drawidian" populations of Southern Hindostan lead us back physically as well as geographically towards the Australians, while the diminutive Mincopies of the Andaman Islands lie midway between the Negro and Negrito races.

The diversities of hair, complexion, and cranial characters observed among the modifications of mankind which have been enumerated, may be exhibited in the form of a tabular classification as follows:—

	Leiotrichi.			Ulotrichi.	
	Dolichocephali.		Brachycephali.	Dolichocephali.	Brachycephali
Leucous.					
		Xanthochroi.			
Leucomelanous.					
		Melanochroi.			
Xanthomelanous.					
	Esquimaux.		Mongolians.	Bushmen.	
		Amphinesians.			
		Americans.			
Melanous.				Negroes.	Mincopies (?).
	Australians.			Negritos.	

The "Leiotrichi" are the people with straight and wavy hair; the "Ulotrichi" are those with woolly hair; the "Dolichocephali" are the long-headed people; the "Brachycephali," the short-headed. "Leucous" signifies that the complexion is fair and the hair red or yellow: "Leucomelanous," that the skin is pale, but the hair dark; "Xanthomelanous," that the skin is yellow, brown, or olive, and the hair black; "Melanous," that the hair and skin are both very dark, or blackish.

As a rule, woolly-haired people are long headed; while, on the other hand, broad heads preponderate among the Leiotrichi, and only two of the stocks enumerated among them—the Esquimaux and the Australian—are exclusively long headed.

It is further worthy of remark that an ethnological chart, projected in such a manner that the Pacific Ocean occupies its centre, shows an Australian area occupied by a dark-skinned, smooth-haired people, separated by an incomplete inner zone of dark and woolly-haired Negroes and Negritos, from an outer zone of comparatively pale and smooth-haired men, occupying the Americas, Asia, North Africa, and Europe.

Having thus sketched the physical differences of the chief persistent modifications of mankind, the lecturer proceeded to consider the nature and the value of their other differences, linguistic and physiological. Great as is the value of the scientific study of language, philology cannot afford any basis for ethnological classification, unless it can be shown that the mixture or substitution of languages is always accompanied by a corresponding mixture or substitution of the blood of the people speaking those languages. If in any instance it can be proved that the language of a nation has changed fundamentally, while its blood has remained wholly or comparatively unmixed, or *vice-versâ*, language ceases to be a test of ethnological affinity. Cases were adduced in support of each of those alternative propositions. With regard to the physiological differences of the known persistent modifications of mankind, there would appear to be good grounds for the belief that they are differently affected by the influences which give rise to diseases, but no sufficient evidence has yet been adduced in support of the doctrine held by some ethnologists, that any two of them exhibit the phenomena of hybridity.

Turning from the present to the past condition of mankind, attention was directed to the fact that our knowledge of most of the persistent modifications of mankind is very modern, and of later date than the fifteenth century; while, on the other hand, the oldest historical records give us no right to believe that the distribution of

mankind was, at the time to which they refer, other than it is now.

Archæology proves the existence of dolichocephalic and brachycephalic people side by side, or in succession, in various parts of Europe but affords no grounds for believing that they were different from stocks now existing in the same or adjacent localities ; while, at present, palæontology does little more than reveal the existence of man in that quarter of the world before its physical condition had become that which it now is.

The lecturer finally proceeded to discuss the various hypotheses which have been offered to explain the facts of ethnology, pointing out that the strength of the Monogenists lies in their recognition of the anatomical unity of mankind while the Polygenists have done no less service by bringing prominently forward the distinctness and permanence of the leading modifications of the human type. And in conclusion, he endeavoured to show in what way the application of Mr. Darwin's views to Ethnology reconciles the doctrine of anatomical unity with that of persistence of modification, and overcomes difficulties of distribution by taking into account the effects of geological change.

VII

EXPLANATORY PREFACE TO THE CATALOGUE OF THE PALÆONTOLOGICAL COLLECTION IN THE MUSEUM OF PRACTICAL GEOLOGY. (1865.)

§ I.—*Preliminary Considerations.*

THE formation of the collection of fossils in the Museum of Practical Geology has been a necessary result of the operations of the Geological Survey of Great Britain, whose officers have been engaged for many years past in determining the structure of the British islands; that is, in ascertaining what is the nature and the order of superposition of the various irregular masses or regular "strata,"[1]

[1] *Stratum.* A single layer of the earth's crust, whatever its composition, is technically termed a stratum. For simplicity's sake, the often highly irregular masses of igneous rock which enter largely into the composition of the earth's crust, and which might not technically be termed "strata," may be left out of consideration.

piled one upon another, which compose these, like all other parts of the earth's crust.

If rocks and stones were soft and easily cut nothing would be easier than the solution of these questions. It would be merely necessary to make a sufficiently deep vertical cutting of the country in any required direction, and the true order of the beds would be at once visible on the walls of the section. But, it is needless to say, that in practice, cutting into rocks is a very difficult and a very expensive operation ; and that the making of such artificial sections as these, for geological purposes, is wholly out of the question. The geological surveyor is, therefore, obliged to trust very largely to the accidental occurrence of natural sections, such as are afforded by the sea cliffs, or the scarped hills, which may occur in his line of work, and to such artificial aids as are incidentally yielded by the sinking of shafts or the cutting of railroads.

It becomes, consequently, of essential importance to him to possess a means of identifying the beds which he finds in one section with those in another. Similarity or dissimilarity of mineralogical composition will not always help him, as this quality not only varies in the same stratum, but is similar in widely different strata ; so that beds of limestone in one place may correspond as regards age and position with sandy or clayey strata, elsewhere. On the other hand, the continuity of a stratum between any two points examined would be clear and decisive as to its identity at the two points, but this evidence for the reasons just stated, is but rarely attainable : and where, as so frequently happens, the strata have been disturbed from their original, position, widely separated, or partially destroyed, between the two points, it becomes hopeless to seek for any such proof. Were there no other test of the nature of a stratum at any given point than its mineral character, and its continuity with some other stratum whose place in the series was known, we might have a series of local topographies, but no science of geology ; nor could those great laws ever have been established by which the geologist, acquainted with the surface rock of a country, is enabled to predict with much confidence what may, and what cannot, be found beneath it.

These laws are in truth entirely based on the study of the "fossils" contained in the rocks ; it is upon this science of fossils, or "Palæontology,"[1] that another and most important method of determining the nature and order of the strata rests. Universal experience has shown that every series of strata contains assemblages of fossils which are

[1] *Palæontology*. Derived from three Greek words, signifying, "ancient" and "being" and "discourse." The science of ancient beings.

peculiar to and characteristic of it; which are usually found in it, and never found out of it; and observation has further demonstrated that the strata thus characterized are arranged in an order of superposition which is everywhere constant. It follows, therefore, that the fossils contained in a stratum of rock are capable of revealing to us, at once, the position of that stratum in the whole series, and of informing us what lies above and what below it.

A common example will illustrate the practical value of the information thus obtained.

It is shown by experience that in these islands extensive beds of good workable coal are never found below that particular series of strata termed, collectively, the "carboniferous formation." Nevertheless, fossilized vegetable matters occur in other strata, and have not unfrequently misled owners of estates into undertaking ruinously expensive and wholly fruitless mining operations, which would never have been commenced had they availed themselves of the information afforded by the fossils of the surface rocks. For it is clear that a preliminary examination of these fossils will show at once whether they belong to strata below the carboniferous rocks or above them. If the former be the case, then the sinking a shaft is absurd, as every blow of the pickaxe must take the miner, in reality, further away from the object of his search; if the latter, on the other hand, success is at any rate possible, though the expediency of making the attempt will depend upon many contingencies.

Now it is clear that, if the fossils contained in the rocks constituting the surface in every district of Great Britain had been examined, it would be possible, by colouring a map of these islands, in such a manner that all those parts whose fossils indicated their inferiority to the carboniferous formation should be blue, and all those which lay above it should be red, to indicate at once to the miner where his search for coal might possibly be successful, and where it must neces sarily fail. And furthermore, if the fossils on which the colouring was based were placed in a Museum for public inspection, it would be open to every one to examine for himself the evidence on which the map stood, and to satisfy himself of the accuracy of this part of the work of the surveyors.

What is here supposed to be done with reference to this one set of beds—the carboniferous formation—has, in effect, been performed by the labours of the Geological Surveyors of Great Britain for all the strata which enter into the composition of the British islands. The place where each constitutes the surface rock is marked by an appropriate colour on the maps of the Survey. The fossils which

have served as the standards of comparison in determining the nature of the strata are open to general inspection in the Museum of Practical Geology. In one sense, therefore, the collection of fossils is simply the product of, and key to, the maps of the Survey.

Important as it is, however, to the welfare and prosperity of the country, that an accurate record should exist of the composition of its share of the earth's crust, whence the miner, the metallurgist, and the mineralogist, extract so many products of the utmost value to man, and, indeed, indispensable to the maintenance of his present complex state of civilization ; to suppose that this immediate and so-called "practical" object of the collection is the only, or even the most important end that it subserves, would be as great an error as that of the barbarous Oriental, who sees nothing but a convenient stone quarry in those massive pyramids, on whose walls the instructed Eastern traveller reads the history of an ancient world, and learns the more, the more knowledge and capacity he brings to the inquiry. In truth, the history, not merely of one, but of a series of ancient worlds is written upon the rocks which compose the solid coating of the globe, in signs the meaning of which is decipherable with far more ease and certainty than that of hieroglyphic or cuneiform inscriptions ; or we might say that, as it is the custom in these times to deposit the coins and medals of the age under the foundation stones of a building, so the Great Artificer has, as he laid each course of stone in the world's foundations, deposited coins and medals of *his* striking,—the remains of the then existing system of organic life ; the bones and shells of the contemporaneous living beings.

But a history in an unknown tongue can be profitable only to those who will take the trouble to acquire a knowledge of the construction of the language, and of the signification of its words and signs. Now, Natural History—or the science of the structure and habits of living beings—is the grammar and dictionary of the language of fossils. To understand all that fossils teach, natural history must have been the study of a life ; but a clear comprehension and careful recollection of a few of its simpler principles will be sufficient to enable a person of intelligence, unversed in science, to apprehend the wider bearings of the collection. To afford this assistance is the sole object of the present Explanatory Preface. It is intended to awaken even the casual visitor to a sense of the profoundly interesting problems which the collection forces upon our consideration ; to enable him to comprehend how it is that the naturalist reads here, as plainly as if it were stated in to-day's paper, and with

considerably more faith than he would place in any mere human affirmation that the earth has undergone a great series of changes stretching over enormous periods of time; that its living population has not always been what it is now, but that the present kinds of animals and plants have been preceded by others widely differing from them, and these by others, and so on, for an indefinite series of alternations; that these changes have been accompanied by constant alterations in climate and in the level of the land and sea; finally, that the period of time of which these records furnish the history is inconceivably immense.

These are weighty articles of belief, and nothing can seem, at first, to be less likely than that the accumulation of oddly marked and shaped stones, which are visible on the shelves around, should contain abundant evidence of their validity and truth; but so it is. How it is, will be rendered clear by what follows.

§ II.—*Brief Exposition of those principles of Natural History which are of most importance to the understanding of fossils.*

It has been stated that natural history is the key to palæontology, and hence, before attempting to learn the meaning of fossils, it is necessary to be acquainted with those principles of biological science which bear most directly upon the subject.

1. The most important of all the generalizations of natural history, and, indeed, one of the most brilliant additions which the progress of modern science has made to human knowledge, is the law that all animals and plants, however infinitely various their forms may seem to be, are, in reality, constructed upon a very few plans; in other words, that the parts of animals and plants are associated and arranged according to certain fixed laws.

Thus, to select an example from the animal kingdom. There is an immense variety of hoofed ruminating animals; antelopes, sheep, oxen, deer, giraffes, camels; but notwithstanding the extreme difference in the aspect of these well-known creatures, the anatomist discovers that they exhibit a great number of common characters. Thus: *a.* All possess a backbone, or vertebral column, separating the great centres of the nervous system from those of the alimentary and circulatory apparatus, and the latter is situated on the ventral, front, or downward face of the body; none have more than two pairs of limbs; the chief central nervous system is not pierced by the alimentary canal. *b.* All have a heart with four cavities; possess lungs and a midriff or diaphragm; and have two facets on the hinder part of

the skull, for articulation with the foremost bone of the spinal column. In all, each half of the lower jaw is in a single piece, and is articulated directly with the skull by a convex head; they all possess mammary glands for suckling their young. *c.* The teeth are in all more or less deficient in the front part of the upper jaw: they all possess complex stomachs, and not more than two completely developed long bones in the middle region of the fore and hind feet.

It would be easy to make a drawing embodying all these peculiarities, and that drawing would stand in precisely the same relation to the group of "ruminants" (technically called "*Ruminantia*") as the ground-plan of a single house does to the street which the architect means to build of houses of that size and general form. The superstructure of each house may, if the architect pleases, be totally different in style, without in any way interfering with his general plan, and similarly, in each particular ruminant, the common plan is preserved, while the details of the "elevation," the size, the figure, the proportions, the ornamentation in the way of colour and horns, vary to an immense extent.

Having thus acquired a notion of the "common plan" of the *Ruminantia*, it will be found, on turning to other equivalent groups or "orders" of the *Mammalia* (or animals which suckle their young), that a corresponding common plan may be found for each; and when all these common plans are compared together, it will be discovered that there are certain respects in which they agree. All *Mammalia*, in fact, possess the anatomical characters enumerated under the preceding heads *a* and *b*. Hence, a drawing exhibiting these features would serve as a "common plan" of the *Mammalia*, and the common plans of the orders of mammals, *Ruminantia*,[1] *Carnivora*, &c., might be regarded as modifications of the plan of all mammals, in the same sense as each ruminant is a modification of the common plan of all ruminants. But now, if we were to extend our researches further, and compare mammals with birds, reptiles, amphibia, and fishes, we should discover a still more remarkable fact, viz., that all these creatures, and only these of all living things, possess the characters enumerated under the first head. Hence a drawing or diagram embodying these characters would represent the common plan of these animals—which are collectively termed the *Vertebrata*; and it would stand in the same relation to the common plans of birds, mammals, reptiles,

[1] Strictly speaking the group *Ruminantia* is only a part of the modern order *Artiodactyla*, but it was convenient here to use the term in its old sense and value.

amphibia, and fishes, as the ruminant plan did to oxen, sheep, and antelopes.

By carrying investigations of this kind into the rest of the animal kingdom it has been shown that every animal whatsoever is a modification of one or other of five great common plans:—the plan of the VERTEBRATA, that of the ANNULOSA, that of the MOLLUSCA, that of the CŒLENTERATA, and that of the PROTOZOA.

It is most important, however, not to form a wrong idea as to the real import of these "common plans." We must regard them simply as devices by which we render more clear and intelligible to our own minds the great truth that the parts of living bodies are associated together according to certain definite laws. Why it is that an animal which suckles its young should invariably possess a double articular surface at the back of its skull, should have the articular surface of its lower jaw convex or flat and not concave, and should always be provided with hairs, and never with feathers, we know as little as why the earth turns from west to east, and not from east to west; but if the morphological law which expresses this invariable co-existence, or correlation, of organic peculiarities has been as regularly verified by our experience as the astronomical law, we may, for all practical purposes, reckon as securely upon the constancy of the one relation as upon that of the other.

It is, indeed, remarkable to how great an extent we *may* depend upon these laws, and how seemingly unimportant, and, in the present state of physiology, inexplicable, many of the most constant correlations of animal parts are. Thus the profoundest of "teleologists"[1] will, probably, hesitate to attempt to account, by any physiological reasoning, for the above stated invariable occurrence of true hairs in those animals only which suckle their young and have two occipital condyles; but nevertheless, if a single hair be placed before a naturalist, he will be able, in many cases, not only at once to decide that the animal to which it belongs possesses a backbone, has four limbs, suckles its young, has a heart with four distinct cavities, possesses lungs; but he may be able to go into minute details as to the structure of its brain, and the arrangement and number of its teeth. How does he know these things? Simply because experience teaches him that the structure of the hair in question is found as a constituent part of only one particular plan of organization, and therefore may be depended upon as an indication of all the other peculiarities of that plan. Just as when a particular characteristic fossil is found we may predicate what other fossils will

[1] "*Teleology*," the doctrine of final causes. "*Teleologist*," one who seeks for the final causes of phenomena.

be found in the same bed, without having the least idea of the why and the wherefore of the association ; so the apparently trivial and unimportant hair indicates, we know not why, all the other structural peculiarities which experience shows to be associated with it. We shall find the application of these truths bye and bye, in considering the methods by which fossils are determined.

Important consequences flow from the fact that the forms of living beings are modelled upon common plans, and from the kind of relation which exists between any actual form and its plan. Thus the vertebrate plan, as has been seen, undergoes five modifications, each of which constitutes the common plan of a large assemblage of animals —of mammals, of birds, of reptiles, of amphibians, and of fishes ; and if we select any one of these subordinate plans, we find it again modified so as to constitute the plans of the minor subdivisions of these great assemblages. The reptilian plan is modified in one way to form the plan of the turtle tribe, in another to constitute that of the crocodiles, in another that of the lizards, of the snakes, and so forth. And, in like manner, the common plan of any great division of the animal kingdom is seen, in nature, to be modified into a series of more and more altered and specialized plans, each of which is common to the members of a progressively smaller subdivision of the group, until at length we arrive at the smallest assemblage of beings which can be said to possess a particular common plan ; or, in other words, which exhibits characters common to all its constituents, and not possessed by those of any other group.

It is by reason of these singular relations among the forms of living beings that what is termed a "natural classification" is possible. In the ordinary business of life, whenever it is necessary to recollect and have at command a multiplicity of objects, we "classify" those objects ; we arrange them in groups or packets distinguished by particular marks and having a particular order. Thus it is that the merchant arranges his wares, the librarian his books, the lawyer his papers ; and the naturalist, in like manner, would find it utterly impossible to grapple with the details of the two or three hundred thousand distinct forms of living beings which are the object of his study, unless he could in some way classify and arrange them.

Now the aim of classification may vary. Many persons imagine that Natural History is the knowledge of the names which have been affixed to animals and plants by men of science ; and the wish of such persons is to have a classification so contrived as to enable them, with

the least possible trouble, to ascertain what name has been affixed to an object, or, better still, to determine that no name has been given to it, when they have the satisfaction of baptizing it themselves. These "Naturalists," necessarily, desire in a classification only a good index and dictionary of the names of animals and plants, and it matters not by what marks they designate their groups, so long as those marks are easily discoverable and readily remembered. Thus, plants might be divided according to the number of stamens in the flower, while animals might be classed according to the number of their teeth, the shape and number of their legs, &c.; and arrangements of this kind, if skilfully made, might have no small value and use in helping us to discover what animals and plants are, and what are not known; but it is clear they would be purely arbitrary; there would be no necessary relation between the members of the various groups beyond the single point in which they agree; in other words the classification would be "artificial" and not "natural."

But the low conception of the objects of the science of Natural History, from which such artificial classifications flowed, has given place to other and higher views, and with it all artificial systems have become exploded, or relegated to their proper place as mere aids to the memory. The naturalist of the present day, in fact, stands to him of the past in the relation of a Niebuhr, a Hallam, or a Guizot, to the gossiping compiler of a *chronique scandaleuse*, or, at best, to a Froissart or a Burnett. Without despising the importance of a knowledge of the names and habits of living beings, he sees beyond this, and overruling it, a higher and a nobler aim—the investigation of the laws of life, of the principles discoverable amidst the multiform structures of living beings, and of the relations in which they stand to one another and to the surrounding universe.

For such objects an artificial classification is useless, if not obstructive. The laws of life can only be obtained by observation of the facts of life and generalization from those facts, and the philosophical naturalist seeks that classification which shall best enable him to remember facts and generalizations already won, and shall most efficiently assist him to obtain others.

As Cuvier has well expressed it, modern classification endeavours to throw the facts of the structure of living beings into the fewest possible general propositions. Each living being, therefore, has been compared with all others, and those from which it is not separated by any constant difference are grouped together as one "species." The different species have next been compared, and those which agree in some one or more characters, while they differ from all others in these

characters, are arranged into a larger group, called a "genus." By a like procedure, genera have been grouped into "families;" these into "orders;" orders into "classes," and classes into "sub-kingdoms," which last are the primary subdivisions of the animal and vegetable "kingdoms" respectively.

The resemblances and differences upon which these groups are founded, being based on a comparison of the whole organization of living beings, are thorough and fundamental, and, as it were, indicated by nature herself. Hence this mode of classification has been termed "natural," in contradistinction to those previously referred to, the divisions of which are founded on insulated and superficial relations.

But it is obvious that if animals and plants were not constructed upon common plans, it would be impossible to throw them into groups expressive of their greater or less degree of resemblance, such as those of the natural classification. In fact, the doctrine of "common plan" and of "natural classification" are but two ways of expressing the great truth, that the more closely we examine into the inner nature of living beings, the more clearly do we discern that there is a sort of family resemblance amongst them all, closer between some, more distant between others, but still pervading the whole series.

There is yet another way in which this doctrine has been expressed. In every group there is some average form; some form which occupies a sort of central place, around which the rest seem to arrange themselves; and this form may therefore be taken as the representative of the group, as the nearest actual embodiment of the common plan. Such a form is commonly called the TYPE of the group, and in this sense an antelope might be termed the Type of the *Ruminantia;* a dog, of the *Carnivora.* It is in this sense that the word "Type" will be used in these pages; but it is proper to remark that the term is not uncommonly applied to the most characteristic and marked form of a group. In this sense a cat rather than a dog would, perhaps, be selected as a typical carnivore.

The phrase "family resemblance" has been used above, and it, perhaps, expresses better than any other, the sort of likeness which exists amongst the members of a natural group; specific and generic alliance having the same sort of relation as brotherhood and cousinhood But it is important to remember that the classification of animals and plants stands on its own basis, and is entirely independent of physiological considerations. For the purposes of the classifier it is wholly immaterial whether, as some maintain, "species" are immutable, and have taken their origin independently of one another, directly from the

hand of the Creator: or whether, as others think, they are indefinitely modifiable, and have all resulted from the changes induced by external influences upon some common stock. If all forms of living beings were fossil, and we knew nothing about life, the natural classification of animals and plants would be exactly what it is now; except as it might be affected by the resulting deficiencies in our knowledge. At the same time, the inquiry into the permanence or modifiability of species is, in itself, of the highest importance and interest; and it will be necessary to advert to the bearings of the little definite evidence we at present possess upon the subject, in some of the following pages.

2. *The characters of the sub-kingdoms and classes of the Animal Kingdom.*—A verbal statement of the distinctive characters of a group of animals, or a "definition" of that group, is a description of the "common plan" of structure of its members, and may be made for all groups but with different degrees of precision and completeness according to our knowledge of the group, which is sometimes full and accurate, sometimes scanty and vague. In the latter case it becomes necessary to substitute for a definition of a group, a description in its typical form.[1]

The typical forms of the sub-kingdom, which contains the smallest, humblest, and least complex forms of animal life, the allies of the sponge and the infusory animalcule, called the PROTOZOA, are too small to be visible with the naked eye. The *Gregarina*, type of the GREGARINIDA, is a parasite which abounds in the intestines of many of the lower animals. It consists of nothing but a mass of protein[2] substance inclosed within a structureless outer coat, and containing a clear space with a central particle, the so-called nucleus. During life, the creature exhibits only changes of form; its food is taken in only by imbibition, and no organs for the performance of particular offices in its economy have yet been discovered. Even less complex animated molecules constitute the active agents in the formation of the minute calcareous shells of those RHIZOPODA which are termed *Foraminifera*, which swarm at the bottom of the sea and upon sea-weeds, and by their accumulation are, even now, forming masses of calcareous rock at the bottom of the Atlantic and other oceans.

The rhizopod *Polycistineæ* present even more graceful forms, but

[1] A Tabular arrangement of all the classes and orders of the animal kingdom is given at the end of § III.

[2] *Protein* is a chemical compound found in all living beings, and exclusively in them. It consists of carbon, hydrogen, oxygen, and nitrogen.

have their skeletons composed of silex (the material of flint), and they differ again from the ordinary *Foraminifera*, in being pelagic in their habits—that is, in floating freely at the surface of the sea. In these respects, and in the nature of their skeleton, they resemble other members of the same group, the *Thalassicollidæ*, but in these last the skeleton is frequently in the form of spicula or needles of various forms, and they form aggregate gelatinous masses, which cover vast tracts of the surface of the ocean, the voyager frequently sailing through them for days together.

In the usual spicular character and silicious nature of their hard parts, and in their habit of forming large aggregate masses, the SPONGIDA resemble the *Thalassicollidæ*, but the sponges have a definite cellular organization, are fixed to submarine bodies, and exhibit the first approximation to an alimentary canal, in certain channels, traversing the mass and communicating with the exterior by definite excretory apertures.

All these lowly forms of animal life are, however, unprovided with definite and distinctly formed mouths, and hence they are termed the PROTOZOA ASTOMATA, or mouthless Protozoa. The other PROTOZOA have distinct and permanent oral apertures and even a gullet —whence they are termed STOMATODA. The existence of a more complete alimentary canal in any Protozoon is as yet a matter of doubt, and it is still more important to remark the absence of any trace of a nervous system. The *Vorticella*, or bell-animalcule, so common on the weeds in our fresh-water ponds and ditches, and the *Noctiluca*, one of the most frequent causes of the phosphorescence of the sea, exemplify the division of the *Stomatoda*.

The sub-kingdom CŒLENTERATA contains the great majority of those animals which are commonly known as Polypes, and of which the sea-anemone, and the common fresh-water *Hydra*, are the most familiar examples. Conceive a cylindrical body, fixed at one end, and having an open mouth at the other, surrounded by a circle of armlike tentacles, and you have a good general idea of a cœlenterate animal. But the main characteristic of these creatures is, that their body-wall is composed of two distinct membranes, an inner and an outer; that no trace of a heart or of respiratory organs has been discovered in any of them; that a very simple nervous system has been found in only a very few; and lastly, that the cavity of their body and that of the digestive apparatus are in direct and free communication.

Two great divisions have been established in this sub-kingdom. In the one, that of the HYDROZOA, the walls of the digestive cavity are not distinct from those of the body, while in the other, the

ACTINOZOA, the digestive sac is, as it were, suspended within the cavity of the body.

The Sertularian Polypes, the *Velella*, the Portuguese man-of-war, or *Physalia*, the jelly fishes, or *Medusæ*, are examples of the former division; while the sea-anemone, the *Beröe*, the sea-pen, the red coral, and the madrepore, all belong to the latter.

In the members of all the remaining divisions of the animal kingdom, the VERTEBRATA, the MOLLUSCA, and the ANNULOSA, we find, as rules to which there are very few exceptions, that there is a distinct nervous system; that the alimentary canal is quite distinct and shut off from the cavity of the body; that there is a distinct circulatory system; and that there are special respiratory organs.

To the first of these laws no exception is at present known, and it is doubtful whether any exists to the second. To the third and fourth the exceptions are absolutely numerous, though few relatively to the whole.

Not only are the three higher sub-kingdoms thus clearly marked off from the lower two, but there is a very sharp line of demarcation between the highest of the three, the VERTEBRATA, and the two others. In all vertebrate animals the central portion of the nervous system, commonly known as the brain and spinal marrow, is nowhere pierced by the alimentary canal; it lies on the side of the alimentary canal, opposite that towards which the limbs are directed; and it is separated from the alimentary canal by a complete partition, in which, at one period of the animal's existence, there lies a peculiar cellular cord-like structure, the "chorda dorsalis." Again, in the development of the vertebrate embryo, a longitudinal groove appears in the plate-like rudiment of the body, in which this central nervous mass is developed, and plates grow up on each side of the groove, eventually uniting together above, to form that spinal canal and skull cavity, in which the central nervous system of the vertebrate animal is always contained.

It is by these characters that the VERTEBRATA differ from all other animals whatsoever, and not, as their name implies, by the possession of "vertebræ." "Vertebra" is the name given to each of the distinct bones of which the backbone of the majority of the VERTEBRATA is composed; and the backbone or vertebral column is nothing more than the central portion of that partition between the alimentary canal and the nervous centre already described. Now, in many of the class of fishes—such, for instance, as the lamprey—the partition exhibits no such distinct bones, contains hardly any bony

matter at all, in fact; and hence such vertebrate animals have no vertebræ.[1]

All known VERTEBRATA have distinct organs of circulation and respiration. The sexes are hardly ever combined in the same individual; the products of a single ovum never divide into several portions, which continue to pursue an independent and contemporaneous existence. The sub-kingdom is divisible into five classes: PISCES, AMPHIBIA, REPTILIA, AVES, and MAMMALIA.

PISCES, or fishes, are aquatic animals, breathing by means of gills. Their heart usually consists of a single auricle and a single ventricle; their nostrils usually do not open into the mouth; their vertebræ are commonly bi-concave; their shoulder girdle is, in a large proportion, attached to the head; the fore and hind limbs have the form of fins. They frequently possess an air bladder, but only in very rare cases does this organ assume the form and functions of a lung. The body of fishes is very generally covered with scales, and most, if not all, possess a peculiar tegumentary apparatus—the so-called "mucous canals." They are almost always oviparous and cold-blooded.

It will be observed that not one of these characters is given without a qualification; and indeed it is impossible in the present state of science to frame an unqualified definition of this class which shall include all its members, and exclude all others. This difficulty is caused by the close approximation of some members of the next class to fishes.

The AMPHIBIA (frogs, newts, &c.) pass a portion of their existence under a completely fish-like guise, breathing exclusively by gills, and having a two-chambered heart. Eventually, all acquire lungs and a three-chambered heart, but some, such as the *Proteus*, never completely shake off their piscine character, retaining their gills, even after they have acquired lungs; while others, such as the frog and toad, undergo a wonderful metamorphosis, completely losing the fish-like character of the tadpole and becoming air-breathers, and more or less completely terrestrial in their habits.

[1] This is only one of the many instances that might be adduced of the advantage of a classical over an Anglicised nomenclature. The question is frequently asked, Why is science made more difficult by the use of Greek and Latin terms, when English ones would do as well, and give everybody information at the same time? The answer is, that as science advances, the definition of a group alters, and frequently becomes entirely different from, or even contrary to, what it was. To change the name would simply be to cause inextricable confusion; and it is therefore desirable to have some term which shall not too strongly suggest a meaning, which shall, in fact, readily pass into a mere proper name.

But no amphibian hitherto known, however fish-like, has its pectoral girdle attached to its head, nor have the mucous canals and sacs so characteristic of fishes been yet discovered in AMPHIBIA. The limbs, when they exist, are constructed upon the same plan as those of the higher Vertebrata.

It is difficult then, with our present knowledge, to give characters which will absolutely separate fishes from AMPHIBIA, but these two classes are very distinct from all other VERTEBRATA. In reptiles, birds, and mammals, even the young embryo is distinguishable from that of a fish or of an amphibian, by the possession of two membranous structures, one of which is called the amnion, and the other the allantois. The former constitutes a sort of bag investing the whole body; the latter is a sac upon which many vessels ramify, and which, among other functions, subserves that of respiration, before the proper respiratory organs are developed.

Furthermore, while all fishes and AMPHIBIA possess gills at one period or other of their existence, reptiles, birds, and mammals never exhibit a trace of such structures. They respire first by the allantois, afterwards by lungs.

The heart in the higher VERTEBRATA is usually divided more or less completely into four cavities.

REPTILIA and AVES are either oviparous or ovo-viviparous, and they are provided with no integumentary gland for the secretion of nourishment for their young. MAMMALIA on the other hand are viviparous, and are always provided with such a gland, which is called a "mammary gland." Hence they alone are enabled to suckle their young.

In all reptiles and birds the skull articulates by a single head or "condyle," with the first vertebra of the neck. In all mammals it articulates by two condyles with the corresponding vertebra. In all reptiles and birds each ossified half of the lower jaw is primarily composed of many pieces, and articulates by a concave surface with a bone produced by the ossification of the upper part of the primary cartilaginous basis of the mandibular arch in the embryo, and which is called the "quadrate bone" (*os quadratum*).[1]

In all MAMMALIA, on the other hand, the ossified halves of the lower jaw are never subdivided; the articular head of the lower jaw is either convex or flat, and is articulated in the adult with a bone, which is formed on the outer side of and above the upper part of the primary

[1] To explain all the terms used in these definitions fully would be beyond the province of his explanatory preface. Any elementary treatise on anatomy will supply the deficiency.

cartilaginous basis of the mandibular arch, and is termed the "squamosal" bone. The part which corresponds with the quadrate bone of the reptile or bird becomes one of the small bones of the ear.

Such are the characters which distinguish mammals from birds and reptiles. The latter are clearly defined from one another by many characters. In birds, the anterior limbs are always peculiarly modified so as to form wings; in reptiles, wings are rare, and when they exist are very differently constructed. Birds are covered with feathers, reptiles with scales or osseous plates.

The lungs of birds are fixed to the back of the chest, and almost always communicate with cavities or air-chambers in the body and in the bones. The lungs of existing reptiles are free, and never so communicate. What are called the "optic" lobes in the brain of birds lie on the infero-lateral region of the brain, while they are always superior in reptiles. The metatarsal bones of birds coalesce, those of reptiles do not. Birds have the warmest blood of any of the three higher classes of the vertebrata, reptiles the coldest.

The sub-kingdom ANNULOSA contains all those animals which we know familiarly as insects, besides spiders, crabs, worms, sea-urchins, and star-fishes.

Three great plans, corresponding with as many principal divisions, are distinguishable in these sub-kingdoms; that of the ARTICULATA or ARTHROPODA; that of the ANNULATA; and that of the ANNULOIDA.

In the first the body is always divided into a series of ring-like segments (somites), each of which *may* be provided with a pair of articulated appendages, while a certain number always possess such appendages. The anterior six somites and their appendages go to form a distinct head, which bears the eyes and the mouth.

These appendages are always directed *towards* the side on which the nervous system is placed, and hence, if we consider the nervous system of an articulate animal to correspond with that of a vertebrate, the ARTICULATA may be said to walk with their backs downward.

This nervous system consists of a chain of pairs of ganglia, united by more or less distinct commissures, and the gullet passes typically, between longitudinal commissures of the third and fourth pair of these ganglia, to open on the side of the body on which the nervous system is placed.

In almost all ARTICULATA there is a distinct heart, propelling true blood.

The hard skeleton is always formed by the integument.

In the ANNULATA, the body is often composed of distinct somites, each with its pair of appendages, but these are not truly articulated. The arrangement of the nervous system is generally similar to that of the ARTICULATA, and it is traversed by the alimentary canal. There is no heart like that of Arthropods, but a system of peculiar "pseudhæmal" vessels makes its appearance.

In the ANNULOIDA, finally, the annular structure, but faintly marked in many ANNULATA, becomes, in many cases, completely lost; and even, by secondary development within the originally vermiform embryo, an incompletely radiate appearance may be impressed upon the adult, as in the star-fishes and sea-urchins.[1]

None of the ANNULOIDA possess articulated appendages. None have a head composed of modified somites. Their nervous system consists either of a single ganglionic mass, or of two, or more, masses arranged around the mouth and sending longitudinal cords along the walls of the body. There is no certain evidence that any of them possess true circulatory organs; but, in many ANNULOIDA, a system of peculiar vessels, ciliated internally, and communicating, at one time or another, directly with the fluid in which they live, is greatly developed.

The ARTICULATA are divided into four classes:—The INSECTA, the MYRIAPODA, the ARACHNIDA, and the CRUSTACEA. Of these, the two first breathe air by means of what are termed "tracheæ,"—ramified tubes, which carry air into all parts of the body. The INSECTA have never more than three pairs of legs, and are commonly provided with wings; the MYRIAPODA have always a greater number of legs, and never possess wings.

The ARACHNIDA breathe air either by more or less modified tracheæ, or have no special respiratory organs. They never possess wings, and they are commonly said to have four pairs of legs, but it would be more correct, in comparing them with insects, to say that they have only two pairs, for the two anterior pairs of "legs" of spiders correspond, not with the legs of an insect, but with its jaws.

The CRUSTACEA have either gills, or no special respiratory organs. They are essentially aquatic animals, and their body usually possesses many more than three pairs of appendages. They never possess wings.

The MOLLUSCA, like the ANNULOSA, are divisible into three

[1] So prominent does the radiate form thus become that the star-fishes, &c., are ordinarily regarded as the type of a distinct sub-kingdom, "Radiata."

groups:—The *Mollusca* proper or ODONTOPHORA, the LAMELLIBRANCHIATA, and the MOLLUSCOIDA.

The first division is characterized by possessing three pairs of principal ganglia,—cephalic, pedal, and parietosplanchnic. The alimentary canal passes between the two former to open in the mouth, which is situated on the same side of the body as the great nervous centres. The mollusk, similarly, creeps upon its "neural" surface, and in all these respects agrees with the articulate and differs from the vertebrate animal. But it differs from the articulate animal in that its body is not divided into segments, and possesses no jointed appendages; while many Mollusks simulate VERTEBRATA, in having a more or less completely developed cartilaginous case around the nervous centres; but there is no chorda dorsalis, and there is evidence to show that this cartilaginous capsule is widely different, in a morphological point of view, from the Vertebrate skeleton. Many ODONTOPHORA possess a shell, which is developed from the integument, and may be either external or internal. In the former case, it has always at first the form of a single symmetrical cap, the apex of which is directed towards the back and away from the anus.

The ODONTOPHORA possess a peculiar masticating apparatus, the so-called "tongue," which is essentially a ribbon-like band, beset with teeth, and playing over its supporting cartilages, like a chain saw. The chief locomotive organ is the so-called "foot,"—a muscular thickening of the neural and lateral portions of the body.

The ODONTOPHORA are divisible into the CEPHALOPODA, the PTEROPODA, the diœcious and monœcious GASTEROPODA, and the PULMONATA, whose characters may be gathered from the handbooks on Malacology.

The LAMELLIBRANCHIATA are very similar in structure to the ODONTOPHORA, but they possess no buccal apparatus, nor teeth, and their body never undergoes that asymmetrical modification, whereby the primitive form of so many ODONTOPHORA becomes concealed. They always have an external tegumentary shell, and that shell is primitively composed of two symmetrical pieces, one placed on each side of the median line of the back. The foot is usually well developed, always more or less visible, and the branchiæ are lamellar.

In the MOLLUSCOIDA, lastly, the three pair of ganglia, so characteristic of the higher mollusks, and the heart composed of at least one auricle and one ventricle, which these usually possess, are no longer found. The heart in these mollusks is a simple muscular tube or sac. There are no branchiæ like those of the higher MOLLUSCA, but the walls of the pharynx, or possibly, in some cases, the oral tentacles,

perform the respiratory function. The foot is undeveloped. When a bivalve calcareous shell is developed, its halves do not cover the sides of the body, but the front and back part of its dorsal (or hæmal) region. The majority of the MOLLUSCOIDA are fixed by some portion of their dorsal surface to other bodies, and many closely resemble the cœlenterate Polypes in external appearance.

The division MOLLUSCOIDA includes the classes BRACHIOPODA, POLYZOA, and ASCIDIOIDA, the especial characters of which are easily accessible.

Slight as is the sketch which has just been given of the classes of the animal kingdom, it affords an adequate conception of the fundamental differences of plan which distinguish the great types.

But it can hardly fail to have been remarked that there are other respects in which not only the different types but even different modifications of the same type differ widely.

The PROTOZOA, as a whole, are evidently simpler in structure and less variously endowed than the CŒLENTERATA; the CŒLENTERATA than the MOLLUSCA or ANNULOSA, and none of the last approach either birds or mammals in complexity.

Again, a lamprey is a simpler animal than a horse, a worm than a bee.

These indubitable facts are commonly expressed by the phrase that the simpler animals are lower and less perfect than the higher, and this indeed, in one sense, they truly are. But we should greatly err in supposing that *less* perfection implies *im*perfection, or in imagining that the less perfect animal is in any way unfitted for the conditions under which it lives. Were it so, its race would necessarily sooner or later cease to exist. If we look closely into the matter, it will be found that by "less perfect" and "low in the scale of life," one of two things is meant, either firstly, that the creature of which the assertion is made is a less complicated vital apparatus; or secondly, that the parts of which it is composed differ from one another comparatively little in form and structure.

It is worth while to consider each of these cases more fully. Every animal (indeed it might be said every living thing) has in the gross the same kind of work to do—it has to take in the food necesssary for its support—it has to change this into other products and to mould them into its own peculiar form. Lastly, it has to exhibit that kind of reaction upon external impressions which is known as "irritability." Absorption, metamorphosis, and irritability, then are the three great "functions" of all animals.

Now the difference between one animal and another, as to the mode in which these functions are performed, is very similar to the difference which exists between one human society and another, as to the mode in which the affairs of life are carried out. All human wants may be summed up in two words—sustenance and freedom ; but the mode in which men secure the satisfaction of their wants varies with the perfection of their social state. In savage life every man procures his own food, and relies for his security from constraint upon the strength of his own arm. But this state of things is manifestly incompatible with any great advance, either in those arts which minister to the physical, or in those which satisfy the moral nature. If a man has to find his food every day, he will not spend much time in cooking it ; and if he is liable to be attacked by an enemy at all hours, he is pretty sure never to attain to much eminence as a painter or a violinist. By the necessity of the case then, where every man has to do everything for himself, nothing will be done very well ; no man will be much better than another, and none will be very far above the level of mere animal existence.

Contrast this state of things with that which obtains among the active members of a highly civilized society such as our own. Each devotes himself to one occupation, striving to carry out that in the best possible manner ; and trusting to others who devote themselves to other specialities for the satisfaction of all the rest of his wants. There is a "division of labour ;" the wants of mankind are split up, as it were, into a hundred subdivisions, and every man charges himself with the satisfaction of one of these subdivisions, hoping that, in exchange, his own ninety-nine wants will be satisfied by others. So that, in one sense, a hundred civilized men may be said to be the equivalent of but one savage ; while, if, on the other hand, we regard the nature of the products of civilization, and balance the sum of the work done on each side, the advantage on the side of civilization is infinite.

It is precisely this division of the physiological[1] labour of the organisim which constitutes the first of the two great kinds of difference between animals. Some PROTOZOA have no definite aperture for the taking in of food, no muscles, and no limbs. Every part of the body-wall may serve in turn as mouth or locomotive organ. In others there is a mouth, but no definite alimentary

[1] *Physiology*. The science which treats of the forces exerted by living beings irrespective of their forms ; except so far as these contribute to the exertion of these forces.

canal, and the contractile locomotive apparatus is limited to one part of the body. In the CŒLENTERATA the mouth and digestive cavity are permanently appropriated to that office, though not separate from the rest of the cavity of the body. The motor organs are still more definite, and serve as organs of prehension and offence. In the MOLLUSCA the digestive cavity is permanent and completely separated from the walls of the body. A blood system is developed to carry the nutritive matter to all parts of the body. Another portion of the organism is converted into muscle, and can do little but contract; another has nothing to do but to form shell; another, the nervous system and organs of sense, is charged with the sole duty of putting the different parts of the organism in relation with one another, and with the external world. Thus, in the Mollusk, each part of the organism is charged with a special function, and, to the same extent, has become dependent on others. The stomach that digests depends on the blood for its own nourishment. The muscle that enables the animal to seize its prey would perish without the aid of the stomach and the blood, and would be ineffectual without the nervous system which guides it. The Mollusk does no more in the long run than the *Amœba*, it absorbs food, it modifies it, and it exhibits irritability, but the manner in which it does all these things is infinitely superior, and enables it to display powers of which the *Amœba* exhibits no trace.

It is needless to pursue the argument further, or it would be easy to show that the difference between man and the mollusk, as physiological machines, is of the same kind as that between the mollusk and the protozoon; in short, *physiological* perfection is in proportion to the division of the labour of the whole organism among organs specially adapted to particular offices.

The other sense in which perfection is attributed to living beings is morphological.[1] The MOLLUSCA as a whole are more perfect than the CŒLENTERATA, because they exhibit a greater number of specialized and diversiform parts and organs quite irrespective of the functions of those parts and organs; and the VERTEBRATA, in their fundamental character, the possession of a true primordial internal skeleton, exhibit a greater complexity of structure than any mollusk, or any annulose animal.

It of course usually happens that physiological and morphological complexity go hand in hand, but it should be remembered that the conjunction is not a necessary one. The lowest vertebrate animal, for

[1] *Morphology.* The science which treats of the forms of living beings, without regard to their functions.

instance, is in some morphological respects more complex than the highest mollusk, but physiologically it is less so.

One other commonly used phrase, expressive of the relation between different kinds of living beings, requires explanation, as its employment in an erroneous sense has led to grave errors. There is a current impression that the lower animals correspond with the embryonic conditions of the higher; that, in the course of their development, the lower animal advances up to a certain point and then stops, while the higher goes on.

This notion, however, is entirely incorrect; there is no known adult animal which would be regarded by any naturalist as of the same species with any early condition of another animal, if the two were submitted to him for comparison. In no stage of their existence would a competent naturalist regard embryonic reptiles, or mammals, as fishes; in no stage would he take an insect for a worm, or a cuttlefish for any lower mollusk. The whole of this idea, the truth of which has been assumed so often in geological speculations, rests upon a misunderstanding of an undoubted fact, namely, that there is a time in the development of each when all members of a sub-kingdom resemble one another very closely, and that they remain alike for a longer or a shorter period according to the closeness, or remoteness, of their affinity. Thus there is a time when the embryo of a fish could be hardly distinguished from that of a reptile, a bird, or a mammal. But the embryo fish sooner becomes unlike a mammal than the embryo reptile or bird; and the embryo quadrupedal mammal remains longer like a human embryo than does that of a fish or a reptile.

Thus all animals in their youngest condition have, for a longer or shorter time, a similar form, from which each diverges to take its special configuration; if one may so say, they travel along the same road for a shorter or a longer distance, and then each goes aside to its own place. But this is a very different matter from any one form being an arrest of development of another. Of two men travelling together along the great North road, one may be going to Newcastle and the other to York. But it would be a very insufficient and erroneous description of the journey of the one to say that it was merely that of the other cut short.

3. The next great principle of natural history of which some definite notion must be obtained, is the doctrine of what is called the "distribution" of living beings. It is a matter of familiar experience that elephants, lions, and rhinoceroses are not at present indigenous in Great Britain; and humming birds, crocodiles, and

flying fish are as strange to us as are the white bear, the ermine, and the musk ox. Nevertheless, the latter animals are found abundantly in more northern latitudes, while the former swarm within the tropics. Were any one to visit the countries in which the white bear and the crocodile respectively abound, he would discover that there was a certain northern limit beyond which the crocodile was never seen; and, on the other hand, that the white bear never ranges south of a given latitude. In other words, the white bear and the crocodile are found within, or are distributed over, certain limited spaces of the earth's surface, and lines drawn on a globe, so as to enclose these spaces, would indicate the "geographical distribution" of these animals.

There are hardly any species of animals and plants which are not in like manner confined within limited geographical areas, and hence if we were to set out from England, and travel either due south or due north, we should find that a gradual change would take place in the fauna[1] and flora of the countries traversed, their inhabitants differing more and more widely from those of this country the more nearly they approximated either the pole, or the equator. Nor is this result other than might be naturally expected, for we know how closely dependent the health and strength of animals and plants are, upon the amount of heat, light, and moisture to which they are exposed; and in travelling due north, or due south, these climatal conditions necessarily become very greatly altered. A corresponding change in the flora and fauna is observed when, in a mountainous country, we ascend from the plains to the line of perpetual snow; and the animal and vegetable inhabitants of the sea in like manner vary in character and abundance at different depths. But these cases also seem readily intelligible, for elevation has much the same effect on climate as northing; and every fathom of increased depth in the sea corresponds with a certain diminution in the amount of light and a certain alteration in temperature.

Again, there seems to be no difficulty in understanding why, as we find to be the case, terrestrial animals and plants differ from those whose existence is spent in the water; nor why, among purely aquatic creatures, the inhabitants of fresh water are usually widely different from those of the sea. The discrepancy in form seems quite in harmony with the discrepancy in external circumstances.

[1] The term "fauna" is applied to the whole of the animal inhabitants,—"flora" to the whole of the plants,—of a district or country. Thus, the fauna of Africa means all the animals found in Africa; the flora of India—the flora of Kent—means all the plants found in India and Kent respectively. In speaking thus it will be understood that the "indigenous" animals and plants, or those which naturally exist in a country, are alone referred to.

But there are some other facts connected with distribution, the cause of which is by no means so obvious. If the traveller, instead of moving to the north or to the south of this country, journeyed east or west, keeping as nearly as possible within similar climatal conditions, he would, nevertheless, still find that the successive faunas and floras through which he passed were widely different; and if a voyager were to circumnavigate the globe between the parallels of 40° and 60° S. touching at ports in the continents of Africa, Australia and America, the differences between the indigenous animals of each country would be immense, and altogether out of proportion to the changes in climatal conditions.

The globe then may be marked out by boundary lines, some of which run northerly and southerly, and others easterly and westerly, into a number of districts or "provinces," each of which is characterized by a peculiar assemblage of animals and plants. And again, each district might be subdivided by lines parallel with the horizon, into zones of depth and of height, in each of which a certain group of this assemblage would flourish. It must be remembered, however, that neither zones nor provinces are capable of a strict limitation, there being always a border-land between every two in which the inhabitants of both are mixed.

The phenomena of distribution in depth are particularly worthy of attention, from their bearing on geology; for it is obvious that if we are enabled to lay down certain rules with regard to the depth at which particular forms live, we shall be able when we find these forms in an ancient sea bed, to form a judgment as to the depth of that sea bed, and hence, in many cases, to gather valuable indications as to the proximity or distance of dry land. Every one who has walked along the sea shore is familiar with certain forms of life—barnacles, limpets, periwinkles, dogwhelks, shorecrabs—which cover the rocks between high and low water marks. During calm weather he might imagine that these constituted the chief inhabitants of the sea, but should a heavy gale of wind set in landwards, he is soon undeceived, for the waves, tearing up the sea bottom at depths greater than those which are ordinarily exposed by the recession of the tide, cast on shore vast numbers of new creatures, such as whelks, sandstars, corallines, and great masses of seaweed, with whole colonies of animals attached to them, which habitually remain in the deeper regions.

Not satisfied with such accidental revelations, modern investigators have systematised and extended the explorations of marine depths by means of the use of the "dredge," a simple apparatus, long used by oyster fishermen to procure their merchandise, and of course, equally

applicable to the dragging up of other inhabitants of the floor of the sea.

It results from a long series of such observations that at least five zones, each characterised by peculiar forms of animal or vegetable life, may be distinguished at different depths. They are, 1st, the "littoral" zone, corresponding with the interval between high and low water marks; 2nd, the "circumlittoral" zone, extending from low water mark to the lowest limit at which the coral-like plant *Nullipora* is found, a depth, in our latitudes, of between fifteen and twenty fathoms; 3rdly, the "median" zone, characterised by the abundance of POLYZOA and *Sertularidæ*, which it exhibits, and by the predominance of carnivorous forms among its MOLLUSCA; it extends in our seas to about fifty fathoms; 4thly, the "infra-median," and 5thly, the "abyssal" zones lie beyond this, but can be hardly said at present to be well defined. It is in them that our corals and BRACHIOPODA flourish.

The extreme limits of vegetable and of animal life are not known. The higher *Algæ*, such as seaweeds and *Nullipora*, are, in our own latitudes, not found below twenty fathoms; but it is not improbable that the *Diatomaceæ* flourish at the furthest limits of life.

Both the number of species and the number of individuals of animals diminish at great depths. A greater profundity than two hundred fathoms is not to be reached within a very considerable distance of any part of the British coasts; but in both northern and southern seas, living animals have been drawn up from more than three hundred fathoms (or 1,800 feet) below the surface. It is important to remark that the inhabitants of these and still greater depths, however diminished in number, do not appear to become degraded in organisation, but consist of CRUSTACEA, ECHINODERMATA, GASTEROPODA, LAMELLIBRANCHIATA, POLYZOA, and ACTINOZOA, of types quite as elevated as those which are found in more shallow waters, but they are frequently less brilliantly coloured than the latter. While the laws of distribution, as they have been at present determined, therefore, do not enable us to say precisely at what depth living animals can no longer exist, nor even to trace the influence of depth in modifying their forms, they seem, nevertheless, to point to certain assemblages as characteristic of certain ranges of depth. For instance, limpets and periwinkles appear to be absolutely characteristic of shallow water, being found but a very short way beyond tide marks. The lower limit of the plant *Nullipora* on the other hand, seems to mark in all seas the line of demarcation between moderate depths (under one hundred fathoms) and great depths.

We must remember, however, in attempting to apply these generalizations, that as yet distribution in depth has hardly been fairly worked out, even in temperate latitudes, and that before we can safely enunciate laws of general application, a vast number of observations must be made in both tropical and arctic climates.

The fact of the apparently capricious limits which have been assigned to many animals has been alluded to above. That all animals are adapted to the conditions in which they live is a truism, for if they were not so adapted, they would not live, but die; but the strange fact is, that we do not always find animals in those conditions for which they are adapted. At the present day, millions of horses run wild over the Pampas of South America, and these great plains are overspread with a peculiar kind of thistle; there can be no doubt, therefore, that the climatal and other conditions of this part of the American continent are eminently favourable to both horses and thistles. Nevertheless, at the period of the discovery of the Americas, neither the horses, nor the thistles, existed in these regions.

In like manner, eighty years ago, neither horse, nor ox, nor sheep, grazed the wide pastures of Australia; now they flourish and run wild there. The same is true of New Zealand. The little freshwater mussel, the *Dreissena*, now so common in our canals, having swarmed over the whole country, is a recent importation from Eastern Europe. Conditions most favourable for its existence have existed for ages, and yet it only now reaches them artificially. However trite may be the assertion, therefore, that animals are fitted for their conditions, the converse proposition, that conditions imply the existence of creatures fitted to flourish in them, is manifestly untrue.

Again, the existing distribution of animal life furnishes good grounds for exercising the greatest caution in reasoning from the population of one area, however vast, to that of another. A naturalist might be perfectly acquainted with the indigenous animal inhabitants of all South America and Australia, and yet not know that there were such things in the world as the elephant, the rhinoceros, the hippopotamus, the giraffe, the lion, the tiger, the horse, the ox, the sheep, or the goat. He might be fully acquainted with the population of all the enormous area which contains Australia and the Pacific islands, and yet not only be ignorant of the animals just mentioned, but might never even have heard of bears, cats, monkeys, ruminants, sloths, or ant-eaters. Finally, the exclusively African naturalist might fairly conclude from his own experience, that great quadrupeds abound

everywhere, and that there are no such things as kangaroos or opossums.

The commonest facts in distribution, therefore, teach us that it is never safe to apply conclusions based upon the investigation of a limited area, however large, to the animal inhabitants of the rest of the world.

There is yet another caution necessary in reasoning from the facts of distribution. It should be well borne in mind that the connexion between a given form and the conditions in which that form flourishes is, in the great majority of cases, unknown to us. The laws of distribution are for the most part purely empirical; they are merely the expression of observed facts, of the reason of which we know nothing. If we observe species A always in a warm climate, and species B always in a cold one, we may conclude, if we find specimens of A and B, that the climates in which they flourished were respectively warm and cold. The force of the conclusion will depend upon the extent of our previous observation with regard to A and B. In practice, and within certain limits, such a conclusion is probably valid, but it is a very different matter if the argument is put, as it more commonly is, thus:—species A and B are found respectively in hot and cold climates, therefore species (a), which is very like A, though not the same, and species (b), which is very like B, though distinct—indicate that the climates in which they flourished were respectively warm and cold.

This argument, it is obvious, is only valid on the assumption, that a certain amount of similarity of form implies similarity of necessary conditions; and the question immediately arises, how much similarity of form implies how much similarity of condition?

In the present state of science no definite answer can be given to this question. It is not understood why some genera are well nigh universal in their distribution, others limited in their area. No comparison of the osteology of the arctic fox and of the jackal, of the polar bear and of the black bear, of the musk ox and of the buffalo, would enable the anatomist to tell which of these species inhabits an arctic and which a warmer climate. And on the other hand, though the existing species of hippopotamuses, rhinoceroses, and elephants are now exclusively inhabitants of warm climates, it is certain that very similar species formerly flourished in climates at least as cold as that of England, if not much colder.

That these difficulties beset the enunciation of laws of distribution of general application, indicates, what is tolerably certain on other grounds, that the existing arrangement of living beings on

the surface of the globe is a complex result, the product of the interaction of a number of distinct causes. It is pretty clear, indeed, from what we know of life, that the presence or absence of any particular living being, on any given spot of the earth's surface, must depend on these conditions—

1stly. The mode and place of origin of that kind of living being.
2ndly. Its powers of voluntary migration.
3rdly. The extent to which it has undergone involuntary migration, in consequence of changes in the distribution of sea and land; currents, &c.
4thly. The range of climatal and other conditions under which alone it can exist.

If we had these data for each species, its distribution would be a matter of calculation. But unfortunately they are not yet ascertained for any species whatsoever; nor is there, with regard to one or two, that agreement among men of science as to the probabilities of the case, which would be desirable.

Thus, respecting the first condition, no one has ever witnessed the origin of a species, nor is there any scientific evidence as to the mode, or place of origin, of any living thing.

As to hypothetical views, all the possible alternatives have their advocates. There are those who suppose that all living beings were created at once, in one spot, whence they have subsequently migrated; but persons of sound intellect, acquainted with the facts, usually attach themselves to one or two other views. On the one hand, some conceive that all living beings were created as we find them, and where we find them; or that, at any rate, they are the descendants of a stock created within a distance not greater than can be overcome by the voluntary, or involuntary, migration of the species. Those who entertain this view usually suppose that a species, once created, can only be modified to a very limited extent.

On the other hand, their opponents maintain that there is no evidence that species were created as we find them, but that there is reason to believe that all living things are the result of the gradual modification of one or more primitive forms.

Passion and the *odium theologicum* are too often allowed to enter into the discussion of these views. The triumph of either, except so far as it is the triumph of truth, is to the man of science, however, a matter of profound indifference; and in this spirit the arguments on both sides are thus shortly summed up:—

a. Those who maintain the first view urge that all evidence tends

to show that, in the ordinary course of things, living beings can only take their origin from pre-existing living beings; so that, even if the indefinite modifiability of species were admitted, it would yet be necessary to suppose a direct creative interposition in order to account for the first germ of all; and if we admit one direct interposition, it is said, there is no difficulty in admitting twenty or twenty thousand. To this it is replied, that, although there may be no greater difficulty in the one case than in the other, yet the assumption of creative acts, being in reality nothing more than a grandiloquent way of expressing our ignorance of the real connexion of the phenomena and our incompetence to conceive their origination, every reduction in the number of such assumptions is a clear gain to science.

It is furthermore urged that the direct creation of a species is an occurrence which not only has no scientific evidence in its favour, but is, in the nature of things, incapable of being supported by such evidence. For, suppose that in a glass of water, perfectly free from a trace of organic matter, a new species of fish were suddenly to make its appearance before the eyes of half a dozen naturalists, not one of them would believe, or would be justified in believing, that this was a direct creation out of nothing. Philosophically, it would be illogical, and religiously it would be mere superstition, to believe that which is in direct contradiction to our universal experience of the modes of action of the Creator.

b. It is affirmed that, in some cases, animals and plants of the same species inhabit such completely separated regions that their origin, except by independent creation, within their present area is inconceivable. One of the strongest cases of this kind is that afforded by a marine Crustacean, sometimes seen in our fish markets, the Norway lobster (*Nephrops Norvegicus*). This animal is found on the shores of Norway and of the northern parts of the British islands, but not on our southern shores, nor on the Atlantic coast of France, Spain, or Portugal; it reappears, however, at Nice in the Mediterranean, and abounds in the Adriatic about Venice.

There appears to be no doubt that the northern and the southern forms are specifically identical; and it is naturally asked, how could these isolated detachments of one species have migrated to such widely-separated points without leaving some colonies on the only road which is open to them, viz., the western shores of Europe? And if their present distribution is not to be accounted for by migration, how is it explicable, except by supposing that the stock of each detachment was created where we find it?

Were the limits of the land and sea fixed and unchangeable—

were there no such things as geological change—the problem might seem to be insoluble. But the instability of the land and the consequent incessant alternation of dry land and deep sea at the very same points of the earth's surface are the first lessons of the student of geology. This being the case, however, the argument at once loses its force; for if, by the submergence of central Europe, the Mediterranean and the North seas ever communicated, the *Nephrops* would readily have spread from Norway to the Adriatic, or *vice versa*, and when the central mass of Europe rose again, the area of its distribution would be cut in two, and the northern and southern fragments, only, left.

That this is the explanation of the apparent anomaly would be proved if *Nephrops Norvegicus* were found fossil in any of the strata constituting the present land of central Europe. So long as this is not the case, it can only be regarded as a hypothesis more probable than that of special creation at two points, and hence excluding the necessity of adopting the latter.[1]

Many cases of distribution which have been supposed to be similar to that of *Nephrops*, and adduced as such by the advocates of many centres of creation, have been shown to be not really of the same nature, the widely separated forms not being in reality of identical species.

c. The great question, however, upon which the two schools of naturalists divide is, are species permanent? In other words, is it possible that any conditions operating through any amount of time upon any number of generations of a species A, shall give rise to a distinct species B?

In this, as in all other instances where thinking men entertain flatly contradictory opinions, the difficulty of coming to a mutual understanding appears to arise in a great measure from the want of a clear apprehension of one another's meaning. In the present case it is probable that no two persons attach precisely the same signification to the word "species."

Most naturalists admit, indeed, that species have a distinct physiological character, viz., that the intermixture of two species will not produce a fertile race, even if it gives rise to any progeny at all; but, unfortunately, this test is, from the nature of the case, practically inapplicable, not only to the great majority of living animals and plants, but to all fossils.

[1] Species of the genus *Nephrops* have, curiously enough, been found fossil in Central France (Depart. of the Yonne) at a point about half way between the northern and southern area of *N. Norvegicus*.

In practice, therefore, the naturalist is obliged to neglect the physiological characters of a species, and to confine himself entirely to those which can be founded on form and structure. In this sense a species is the smallest group to which distinctive and invariable characters can be assigned.

If, to use a seemingly paradoxical expression, all living beings were extinct—if they were represented by a limited number of fossils, and lay before us as things to be arranged and classified, the practical application of this definition of species would have no difficulty. Sooner or later the whole organic world would be sorted out into the smallest parcels which could be characterized by a definition, and these would be "species."

It is obvious that the task would be equally easy, were all living beings absolutely immutable; if every member of a species were exactly like its fellows, and if all progeny precisely resembled its parentage.

If every dog, for example, were precisely like every other dog, and every puppy exactly similar to its parents, there could be no difficulty about defining the species dog, nor could there be any hesitation in deciding whether a given animal belonged to the species dog or the species wolf.

Unfortunately for scientific ease, no such immutable forms exist in nature. Like everything else in the world, a living being is a compromise, a resultant of all the forces which act upon it; and though like a planet it tends with an immense force to move in a course of its own, yet, like that planet, it is affected and perturbed more or less by all surrounding conditions.

Hence, inasmuch as no two living beings can ever possibly have been subjected to precisely the same conditions, it is not wonderful that no two ever were, or ever will be, precisely alike; nor is it strange that species vary in proportion to the variety of the conditions to which they are exposed.

It is needless to do more than refer to facts which lie within every one's experience. No person is unaware of the difference in the result produced when two seeds from the same plant, or two animals from the same brood, are exposed to widely different conditions in respect of light, warmth, and nourishment.

In all such cases, however, the modification is limited in amount, and no modification of conditions will so mask the characters of the species as to prevent their recognition in either the stunted, or the overgrown, individual. For every individual, therefore, it can hardly be doubted that specific characters are permanent and immutable.

Do what you will with a sheep-dog puppy, you will not turn him into a wolf.

It is obvious, therefore, that thus far, the influence of conditions can be shown to have no appreciable effect in permanently modifying species; for if the offspring of the modified individual were in all respects like its parent before the modification of the latter, it is clear that the whole influence of the modifying conditions would only bring it to the same point as the parent; that the modification in any number of generations would go no further; and that when the influence of these conditions was removed, the species would at once return to its primitive and typical form. Thus, suppose a pair of sheep-dog puppies could be converted into greyhounds by a peculiar course of food and training; for anything which has been yet stated they would produce puppies which would only become greyhounds under a like course, and, if left to themselves, would resume their pure and unchanged sheep-dog character.

Now, in nature this is not the case, by reason of the great fact of hereditary transmission. Every living being is, it has been said above, the resultant of all the forces which *act* upon it; the statement is incomplete unless we add—and which *have acted* upon its parents.

The forces in question are divisible into two classes: the one, more powerful, intrinsic, impressed upon the germ, and causing that germ invariably to tend towards the production of a given form; the other weaker, extrinsic, consisting of all those assisting, modifying, or even destructive influences which reside in the surrounding universe, and which are called external conditions.

For every individual living thing, this distinction into intrinsic and extrinsic forces is absolute; but the law of hereditary transmission obliges us to admit that it may not be so for a series of generations. For hereditary transmission means simply, that a modification undergone by a parent more or less affects its offspring—the offspring tending to reproduce that modification. Thus in the imaginary instance given above, the offspring of the modified sheep-dog, even if placed in entirely indifferent conditions, would have a tendency to assume greyhound characters. The intrinsic force of the germ—its tendencies—would be thus far modified by the influence exerted by external conditions on its parent. The operation of an extrinsic force on one generation may become in the next an intrinsic force.

But it is obvious that if once the influence of hereditary transmission in modifying the tendencies of the germ (and no one denies

it) be admitted, it is very difficult to say where the modification of a given species shall stop.

Here, therefore, is the battle-ground of those who admit and those who deny the indefinite modifiability of species. On the one side are adduced the two indubitable facts, firstly, that certain unquestionable modifications of one and the same species, such as the dog, are (as Cuvier says) more different than any wild species of the same natural genus; secondly, that the admission of indefinite modifiability reduces the production of species to the ordinary course of nature, and accounts equally well for all the phenomena with any other hypothesis.

On the other side are the equally unquestionable truths that specific characters are retained under even extreme modifying influences with great tenacity, and that artificially produced modifications tend, if left to themselves, to return, more or less nearly, to their primitive specific character. It may be doubted, however, if these propositions are really inconsistent with the doctrine of indefinite modifiability.

At present the evidence before the naturalist can hardly justify him in declaring his absolute adhesion to either view; but according as he inclines one way or the other, so will it be probable that his views as to the limits of species will vary. He who leans to the hypothesis of indefinite modifiability will tend to neglect, and he who inclines to that of the fixity of species will tend to exaggerate, minute differences. As the case now stands, those who wish to adhere to the golden mean must put their trust in common sense, a perception of the needs of science, and that sort of tact which can be gained only by incessant practical working at species.[1]

4. So much for those laws of natural history, which help us to understand what the various forms of living beings are, and how they vary. The next most important question is, do animals and plants, as they die, perish and leave no trace behind, or what becomes of them?

The answer to this question must be different, according to the particular kind of animal or plant to which reference is made. The fungus which springs up in a night dies, decays, and is swept away as rapidly; and the soft marine jellyfish or worm may leave no more permanent traces of its existence. Carnivorous and herbivorous animals, again, destroy and efface all recognizable signs of the existence of multitudes even of those living beings which are, physically and chemically, better qualified to endure. Again, though it be a

[1] It should be noted that these pages were written before the appearance of Mr. Darwin's book on the "Origin of Species"—a work which has effected a revolution in biological speculation.

fact, that the great majority of both animals and plants are provided with parts sufficiently hard and indestructible to resist the ordinary causes of decay, for a very considerable time; nevertheless, exposure to damp and change of temperature, in the case of the remains of land animals, and the incessant wear and tear of watery action, among aquatic creatures, would sooner or later destroy, or so deface as to render unrecognizable, the trunks of the hardest-wooded trees and the most solid bones and shells: and this would take place in a space of time, which, however long to us, is a very brief period, geologically speaking, were it not for the very simple but efficient preservative agencies which are brought into play by the very same causes.

The hard parts of terrestrial animals and the remains of land plants are, indeed, to a great extent, destroyed by their exposure to the conditions enumerated above; but, it occasionally happens, that accidental floods sweep them away into low grounds, hollows, or caves, where they rest and become covered up with the fine mud deposited as the waters subside; or living animals may be swallowed up in peat-mosses and in swamps; or their remains may be exposed to the action of springs highly charged with calcareous matter, and thus become coated with carbonate of lime; or the wind may envelop them in drift sand; and in all these instances they will be more or less effectually protected from further change.[1]

The imbedding and preservation of the exuvia of those marine animals and plants which are not destroyed by the carnivorous and herbivorous races, on the other hand, is hardly a matter of chance, but must almost inevitably take place. The sea is incessantly wearing away the shores against which it beats, and the shallow grounds over which its currents and tides race, undermining and cutting them away, and grinding the fragments down by their mutual friction into boulders, shingle, pebbles, sand and mud. It then carries away the finer materials, and spreads them over the deeper and quieter portions of its bed, where they are arranged in successive layers, which gradually rise into banks of mud and sand. Brooks and streams, constantly bringing down similar materials from the higher grounds inland, add to these deposits, or form similar ones peculiar to themselves, thus giving rise to the "deltas" and the "bars" found at the mouths of most rivers. In all the quieter and not too deep parts of the sea bed, therefore, it is as if a constant, though very slow, rain of fine earthy particles were going on, and consequently every dead shell,

[1] Illustrations of the various processes here alluded to are exhibited in Wall-cases 57, 58.

every undestroyed bone, which is left on the bottom, is sooner or later covered up and protected from further destruction. Just as the showers of fine ashes which fell from Vesuvius seventeen centuries ago, so covered up and protected the remains of Herculaneum and Pompeii, that even now the smallest relics of Roman daily life are preserved for our inspection, so may the muddy deposit now taking place over a large extent of the present sea bottom preserve, for the inspection of future generations, the remains of the creatures at present living and dying there.

Some of the contents of the Wall-case 58 are selected for the purpose of illustrating the process which has just been described; they are specimens of the present sea bottom from various parts of the world, and from different depths, just as they were brought up by the dredge. And it will be observed that each specimen, whether of mud or of sand, contains the remains of living beings of one sort or another; nor can there be a doubt that if we could examine the sea bottom in any of the localities from which these specimens are drawn, we should find the mud and sand at a depth of a few feet gradually consolidating into rock, and entombing these shells, &c., as the "organic remains" of the present creation.

For the sake of clearness, it has been provisionally assumed that, in all these instances, the organic bodies have been preserved by being enveloped in masses of inorganic matter; that the mud which forms the bottom of seas and rivers is, in all cases, pulverized rock brought from other localities. It is very rare, however, to find mud purely of this character, and there are some remarkable accumulations at present taking place, of which every particle is derived from organisms which have once lived, the apparent mud, in which the large organisms are imbedded, being nothing but a mass of shells of minuter forms intermingled with fragments of larger ones.

The blocks of hard limestone in Wall-case 58 are portions of a rock now in course of formation over an immense area in the Southern Pacific, and constituting what are known as coral reefs, and coral islets. They owe their origin in fact principally to the corals which abound in that sea, flourishing anywhere between the surface and a depth of fifteen or twenty fathoms. Below that depth the social reef-building corals cannot exist, and consequently if the land were stationary, there would be a sort of margin or fringe of accumulated coral, consolidated by the mud produced by the beating of the waves against its own substance into a "reef," extending outwards until it reached a depth of about twenty fathoms. Such a reef (called a

"fringing reef") surrounds the island of the Mauritius, in the Indian Ocean.

But the blocks in the case have been brought from one of the islets which forms a part of what is termed the Great Barrier Reef of Australia, an enormous mass which extends for a thousand miles, at a varying distance from the eastern shore of that continent. Between the shore and the reef is a shallow sea, not more than thirty fathoms deep, and dotted with coral and other islets; but a few boats' lengths outside the reef, a line of a thousand fathoms long will not reach the bottom. It follows, therefore, that the reef has the form of a steep high wall facing to the eastward, with a shallow fosse on the westward. There is every reason to believe that the coral is here thousands of feet thick, and it can only be supposed that it has accumulated in consequence of a very slow and gradual subsidence of the land, so slow as not to exceed the rate of upward growth of the coral. It is clear that the thickness which a coral reef may attain under these circumstances is practically unlimited.

The pulverizing action of the sea, breaking up and destroying the face of the reef exposed to it, is not the only agent by which coral is converted into limestone mud. Certain marine animals—fishes and other animals—feed upon the live coral, and reduce the calcareous matter to a fine mud, which is passed out in their excrements. Mollusks and worms burrow in the coral, and tend to destroy its cohesion, and the multitude of *Foraminifera*, which find, in the reef, a favourable sphere for their development, add their hard parts to the oozy accumulation. This fills up the interstices of the dead branches of the coral; and the whole becoming compacted, probably by the percolation of water, forms a mass the appearance and hardness of which may vary from those of chalk to those of a hard and ringing limestone. From this entirely organic, to a chiefly or entirely inorganic origin of a rock, every transition exists.

The bottom of the Atlantic has lately been examined, with much care, in the course of the soundings which have been carried on for the purpose of laying down the electric telegraph. Over an area of many thousand square miles, and at depths varying from 1,000 to 2,500 fathoms, the bottom is entirely composed of a fine oozy mud, nine-tenths of which at the very least is composed of the calcareous remains of *Foraminifera*; the rest is partly inorganic, partly consists of the silicious cases of *Diatomaceæ* and *Polycistineæ*.

If this sea bottom were upheaved and could be examined, it would without doubt be found that the older and deeper parts of the mud have hardened into a chalky rock, the thickness of which of course

depends on the time during which these deposits have been accumulating.

5. Most important consequences flow from a recognition of the fact, that the modes of preservation of the remains of animals and plants last described far outweigh every other in importance and extent. This may be made more clear by again using the instance of Pompeii and Herculaneum as an illustration. Suppose that long after these cities were buried, others had been built over them by some of the many barbarian invaders of Italy, during the decline of the Empire, and that after a while Vesuvius had entombed these under another shower of ashes; imagine that five or six centuries after this the Normans had built other cities on the same ground; and that these had, after a few hundred years of existence, undergone a like fate, so that the whole of this part of Italy was buried under volcanic accumulations, on the surface of which flourished the villages and the vineyards of a race ignorant of the existence of a previous condition of things. And now suppose a well to be sunk, or an excavation made for some purpose or other, down to the original foundation of Pompeii; the digger would pass through three layers of volcanic accumulations, separating the foundations of as many cities, differing in the style of their architecture, in their sculpture, their paintings, and their utensils, and clearly showing that they belonged to three separate nations. It would be quite clear, again, to the excavator, that the highest city must be the latest and last built, the lowest the earliest; and he could arrive at no other conclusion than that three several races had flourished and perished, one after another, on this very spot in ancient times. For how great a space of time each race had remained, and what was the absolute antiquity of any one or of the whole, he would be unable to say; but their relative antiquity—the chronology of the series—would be plainly indicated by the order of their superposition.

Exactly the same reasoning is applicable to the beds, or strata, of mud and sand which are now accumulating and gradually hardening into rock at the bottom of our present seas. Those layers which are, at present, being deposited necessarily lie above those which were formed in the same locality a year ago; and these, above those of the preceding year; while, on the other hand, they will be covered up by deposits of future years. Therefore, it follows, that if ever the present sea beds are upheaved, so that their composition may be examined, the future observer will find the beds containing the remains of marine animals and plants superimposed upon one another, in precisely the same order as they are now being formed, the oldest at the bottom,

the youngest at the top; he will be furnished by their order of superposition with an accurate *relative* chronology of the changes which are now taking place; but, without the introduction of other considerations, he will, of course, be unable to assign the ***absolute*** period at which any bed was deposited, or the time occupied in the formation of the whole.

The antiquarian called upon to estimate the probable absolute age of the oldest of the cities in the imaginary case stated above, would be guided by what he knew of the time required to build cities; by historical evidence as to the conditions under which nations replace and extirpate one another; and by physical considerations based upon a knowledge of the mode and rate of the formation of volcanic accumulations of a given thickness: but, even then, he would, probably, prefer to state the minimum, rather than the maximum, antiquity. And so the future naturalist, should he have no other light than the strata now forming themselves afford, can only be guided, in his estimate of their antiquity and of the period occupied in their formation, by his knowledge of the average duration of animal life, and of the rate at which sediment of a given thickness can be deposited. He may as well assume the remains before his eyes to be accidental "sports of nature" at once, as speculate upon any other foundation.

Just as our only means of comprehending the civil history of the past is to apply to ancient times those principles which a careful study of the actions and motives of our contemporaries leads us to believe, are of universal application to mankind; so, in endeavouring to interpret the monuments of the ancient world of geology, we must be guided by what we know of the present creation; and thus having learned what living creatures now exist, how they are constructed, and how their remains are becoming imbedded in the rocks now forming, we are ready to enter upon the inquiry as to what forms of life animated the ancient worlds, how they were constructed, and how their remains have been handed down from those remote ages.

6. There are yet one or two collateral points which require discussion. Supposing that the present bed of the ocean were upheaved, and became exposed to view, so that we could examine the organic contents of all the strata of mud and sand which have accumulated and hardened into stone for the last four or five thousand years, ought we to expect to find, at any one spot, a complete and unbroken series of the remains of all the creatures that have ever lived there? Assuredly not. In the first place, it has already been explained that there are many animals entirely devoid of parts

sufficiently hard to be preservable, and of them every trace would have disappeared. It is important to remark that a naturalist who should become acquainted with the present animal creation only in this way, would be ignorant of the existence of many genera and families, of some orders, and even of one or two entire classes; but no sub-kingdom would be without abundant representatives, and therefore, he would be perfectly acquainted with all the great types of organization at present existing. There would necessarily be defects in his knowledge, but these defects would by no means interfere with his obtaining a very clear and just, though not complete, idea of the present state of things.

But there are other and more formidable sources of imperfection in our Palæontological knowledge. Not only does the very nature of some animals present an insuperable bar to the preservation of a complete record of organic life in the rocks contemporaneously formed, but it is, to say the least, excessively improbable that a complete series of even those organic bodies which are preservable should be found at any one spot. For modern research teaches that the level of the land is constantly changing; slowly, but surely, some countries are rising, while others are becoming depressed; and there is good evidence that, in some parts of the world, several alternate movements of elevation and depression have taken place within a comparatively modern period. Now, whenever the bottom of the sea becomes dry land, or the dry land sinks to the bottom of the sea, there must obviously be an interruption in the series of living inhabitants, aquatic forms replacing terrestrial, or *vice versa*. Thus should the sea bottom be raised into dry land, and then depressed again, so as to be covered with fresh deposits, the whole mass, when subsequently elevated and exposed to view, will exhibit a break in the series of marine organic remains, corresponding in magnitude and importance with the interval during which the sea bed remained in the condition of dry land. It is probable that there is not a single spot on the earth's surface which has not been thus subjected to many alternations of elevation and depression, and, hence, we may safely infer that no single series of superimposed strata can contain a complete series of even those forms of past life which have flourished in that one region.

But, if this be true of those marine animals whose chances of preservation are greatest—whose hard parts contain so little animal matter as to be not worth attack on the part of predaceous organisms which are sufficiently dense to resist the destructive agencies to which they must almost necessarily be exposed before they are protected by

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sediment, and whose locomotive powers are insufficient to enable them to escape by migration, the imminent fate threatened by changes of level; how much more fortuitous must be the preservation of those remains which, like the bones of the marine *Vertebrata*, contain much animal matter, and are comparatively soft, or which belong to entirely terrestrial creatures? And, in fact, it is among the rarest of occurrences to find the bones of a dead wild quadruped, or bird; or to dredge up from the sea bottom a relic of a fish or of a porpoise, abundant as these animals are in our seas.

We turn to the examination of the collection of fossil remains then, bearing this truth clearly in our minds, that at best it contains only an imperfect record of the past; that it is a history, some of whose leaves are certainly torn out—we know not how many or how few—though, judging by the present condition of things, we surmise that their teachings would not contradict any duly limited deduction from the information we derive from other sources.

§ III.—*Application of Natural History to the elucidation of Fossils or "Palæontology."*

1. An important question meets us on the threshold, as it met those who first directed their attention to fossils:—How do we know that these curiously formed bodies, often to all appearance of one substance with the rock in which they are imbedded, really are the remains of creatures which have lived? how do we know that they are not, what the ancients supposed them to be, *lusus naturæ*—sports and freaks of inorganic nature, produced in blind imitation of living bodies, just as the hoar frost on the window pane simulates the foliage of a tree?

We know that fossils are the remains of animals and plants by precisely the same common sense reasoning as that which led Robinson Crusoe, seeing the impression of a human foot on the sand, to conclude that a man had been there. The footmark might by possibility have been an accident—a *lusus naturæ*; but pending the proof that it was so, the precautions of the shipwrecked mariner exhibited the soundness of his judgment. We cannot experimentally prove that fossils are truly the remains of dead animals and plants, any more than we can experimentally demonstrate that the utensils recently brought home from the arctic regions really belonged to the crew of the "Erebus" and "Terror"; but all the facts, the condition in which the things were found, the marks upon them, agree with this hypothesis, and none oppose it. On like grounds, our belief that fossils are the remains of

beings which once lived, has acquired firm hold and remains unshaken; the conditions under which they are found, and all their marks, agree with the hypothesis, while increasing knowledge, so far from shaking, is incessantly, and in very wonderful ways, strengthening the foundations of this, as of every truth.

2. The extent to which it enables us to reason to the unknown is commonly, and in a great measure justly, regarded as one of the best tests of the truth or falsehood of a scientific theory; and none has ever more brilliantly stood the application of this test than that now referred to. For if fossils really are the remains of living beings, we may reasonably expect, in the absence of evidence to the contrary, that the animals and plants of which they are the exuvia came under the operation of the same great law of the invariable correlation of organic peculiarities, which has been shown above to be manifested in the present creation; and it might be fairly anticipated that the same logical process which enables us to reason from the structure of the hair of a recent animal to its whole frame, or from the peculiarities of the wood of an existing plant to its fruit and the minor particulars of its embryology, would be equally available when applied to the extinct inhabitants of the world.

The magnificent researches of Cuvier first practically demonstrated the justice of these surmises, and showed that the laws of correlation of parts deduced from the observation of living animals hold good to a wonderful extent among the extinct forms; so that to one, as thoroughly acquainted as he was with the details of animal organization, an isolated fragment of a fossil bone, or an odd tooth, was, frequently, sufficient to indicate the general affinities of the animal to which it belonged; and to justify him in making those wonderful predictions of what would be the nature of its other parts, which were so often to be verified in the course of future investigations.

One of the most remarkable examples of such successful prediction is that which Cuvier himself mentions as "a very singular monument of the force of zoological laws, and of the use which may be made of them." From the famous gypsum quarries which furnished so many occasions for the display of his genius and knowledge, a block was brought containing the imperfect remains of the skeleton of a small animal; the shape of the lower jaw and the characters of the teeth were such as are alone known to exist in the order of marsupial animals, of which the opossum and the kangaroo are the most familiar examples. But all known *Marsupialia* possess two remarkable appendages to the "pelvis" or bony girdle of the hips, which are termed

the "marsupial bones," because they are connected with the pouch in the female. Here was a law of invariable correlation of anatomical peculiarities (certain teeth and certain forms of jaw being always associated with the presence of these bones), of universal application to living animals; would the law hold good for the fossil? Cuvier was so confident that it would that he invited some friends to witness the picking away of the stone from the region where he believed the marsupial bones would be found; and the result verified his expectation, for the bones were discovered just in that very situation.

3. It will be easily understood, however, that the whole of this train of reasoning is only valid on the assumption that a certain uniformity has prevailed in organic nature; that the structures which we find invariably associated now were invariably associated in earlier times; that, in short, the great laws which are expressed by our conceptions of common plans have always remained the same. We know of no reason, save the invariable occurrence of the co-existence, why a peculiar form of jaw should always be accompanied by the existence of marsupial bones; and just as certain animals now exist in which the marsupial bones are present, while the peculiar structure of jaw is absent, so it is quite within the limits of possibility that, at an earlier period of the earth's history, animals might have existed possessing the peculiar jaw, but deprived of the marsupial bones. Of course, in this case, Cuvier's reasoning would not have been conclusive, and his prophecy might not have been verified.

In point of fact, it would not be safe in all cases to regard the laws of invariable anatomical correlation deduced from the observation of the existing animal world, as applicable, without reservation, to the members of extinct faunas. No generalisation from the structure of existing animals could be better established than that biconcave vertebræ are found, throughout the spinal column, only in fishes and perennibranchiate amphibia, or that hollow bones of a certain form are characteristic of birds; and yet we should be led into most erroneous conclusions by reasoning without hesitation from these data, to the structure and affinities of the animals to which certain vertebræ and certain bird-like bones found in the mesozoic strata belong. In fact, while experience shows, with a constantly increasing weight of proof, that the great laws of the construction of animals have been identical throughout all recorded time, and while, therefore, when we possess any clear indication that a fossil animal belongs to any one of the great groups, we may safely predict that it will exhibit all the other *characteristic* peculiarities of that group; we must be careful to remember

that in many of the smaller groups, combinations of organic peculiarities have existed of a very different nature from those which now obtain; and we must therefore be content to regard many of the established generalisations as only approximatively correct.

As a general rule, however, it is very true that the more we learn of the world of fossils, the more clearly does the conviction force itself upon our minds, that from the earliest times of which we possess a record to the present, no change has taken place in the general scheme of the organic world. There are, perhaps, 15,000 established species of extinct animals, but among them there is not one whose plan of construction differs so far from any now known, as to require the establishment of even a new class for its reception. Different naturalists will estimate the number of classes of animals now living variously, but they may be safely assumed to be at least five-and-twenty—five-and-twenty distinct modifications of the five great primitive common plans; and yet so comparatively slight has been the change since the earliest times, that the whole extinct world will not supply us with a six-and-twentieth modification! If we descend to the next smaller divisions—to the orders—the same fact becomes apparent; at the very lowest estimate there are not fewer than between a hundred and thirty and a hundred and forty orders of animals, and out of these, at the most, not more than fourteen or fifteen are represented only by extinct forms; that is to say, in the whole range of geological series not more than ten or twelve per cent. of ordinal types, different from those which now exist, have come into being.[1]

4. The history told by the records of the organic world is in perfect harmony with that which is written on the face of inorganic nature. The thickness of the crust of the earth, down to the greatest depth to which man has been enabled to penetrate, is to a great extent composed of strata of rock, the physical and chemical peculiarities of which evince their identity with the products of the present operations of nature. Beds of conglomerate containing rounded pebbles demonstrate that the sea beat against and broke up its rocky boundaries then as now, rounding and polishing the fragments by incessant friction as it wears them on any modern shingle beach; fine grained limestones and sandstones show that, then as now, the finer products of their attrition were carried away and deposited, in the form of beds of mud, upon the deeper and quieter

[1] The number of orders is here purposely taken at an extreme minimum; while the highest possible value is given to the extinct groups.

parts of the sea bottom. Vast and frequent interruptions in the regular series of beds prove that, in ancient times as at present, the solid crust oscillated, so that what was dry land became covered by the sea, and what was sea bottom remained for long ages dry land. And, finally, in like manner as we know that, within the period of which man is cognizant, all these changes have gone on in an excessively slow and gradual manner, rapid and convulsive action being altogether exceptional, so we have the clearest proof that the time represented by the vast succession of ancient strata is enormous and almost inconceivable, and that gradual and regular change was, then as now, the rule—catastrophe and convulsion the exception.

Nevertheless, as in the ancient organic world we have found that there is a certain amount of departure from what might be called the bye-laws of the present creation, so it is quite possible that, in the physical world of past times, changes may have now and then taken place, with a rapidity and a violence to which the minute experience of man affords no parallel. An *Ichthyosaurus* is, in one sense, a sort of animal catastrophe, and as we are well assured of the occurrence of this one wide deviation from existing manifestations of the vital forces, so we must not be too sure that corresponding departures from the usual order of the physical world have not occurred in past times.

The same analogies which demand this caution, however, fully justify us in concluding that, throughout all geological time, the great physical forces have obeyed similar laws. The gravitation of matter, its hardness, the effects of heat and of chemical affinity upon it, have been the same, we have every reason to believe, from the Cambrian age to the present; and as a consequence, it cannot be doubted that the vital actions of the trilobites were governed by the same physiological laws as those by which we now live and move and have our being. For, leaving the phenomena of consciousness out of the question, physiology is but an application of physics and chemistry.

5. Now, just as the restorations of the palæontologist imply his confidence in the uniformity of the great laws of morphology throughout all time, so the chronology of geology, the basis of the whole science, rests upon a like assumption with regard to the general uniformity of the laws of physics and chemistry. It would be ridiculous to argue from the superposition of ancient beds, unless we assumed that their constituent particles gravitated in the same way then as now; the identity of mineral character of two beds could prove nothing without the assumption that the laws governing chemical

changes have always been the same; and, in like manner, we can reason on the general habits of ancient living beings only on the assumption that the great laws of physiology were the same then as now. No half measures will avail; we must be prepared either to assume the general uniformity of ancient and modern action, or we must give up the problem, for no other hypothesis affords the least criterion of truth, or the slightest check upon the play of the imagination. But if we may argue from like effects to like causes, then geological chronology is as much a matter of science, and capable of being tested as thoroughly, as any other case of succession.

The arguments on which these chronological considerations are founded are simple and intelligible enough. It has been already proved that, in the present state of things, the lowest of any series of beds which have been deposited from water is of necessity the oldest. If, then, the great majority of the ancient strata have also been deposited from water, if they are nothing but the hardened muddy beds of ancient seas and lakes, (a fact of which there is abundant evidence,) then the same law necessarily applies to them, the lowest stratum is the oldest, and the superjacent beds have all been deposited during a subsequent period. The argument applies with equal force to the whole crust of the earth, and if we could tell how much time was required for the formation of each bed, we should, by adding all the periods together, arrive at the smallest possible interval which can have elapsed since the deposition of the oldest bed. We have no data sufficient to enable us to say, with any approximation to accuracy, how long it takes to deposit sufficient mud or sand to form, when hardened, a layer of rock two feet thick; but we are quite safe in saying that neither lake nor sea ever deposited that amount upon its bed in the course of a year.[1] Now, the total measured thickness of ancient strata, deposited either from fresh or salt water, is not less than 60,000 feet (or about 12 miles), so that, even assuming them to have been deposited, without interruption, at a rate faster than any sea or lake deposits mud nowadays, we should still require a period six times as long as that of which any human record exists, for their formation. But, in truth, when we take into account the probably immensely greater time required for the formation of two feet of sedimentary deposit; the vast amount of rock which has been formed and subsequently swept away by denudation, so that it is not reckoned in

[1] Exceptional deposits, as, for instance, by earthquake floods, are here left out of consideration, as they can have had but little influence on the sum total of the aqueous formations. The total thickness of the latter here assumed is midway between the estimates of Professor Phillips and Sir C. Lyell.

estimating this total thickness of the strata; and the possibility that masses of strata, which will require interpolation in the general series, lie hidden from our view, in parts of the world which have not yet been examined, or under the present bed of the sea; the most sober calculator will hardly venture to limit the factor by which even a period of 30,000 years should be multiplied to give the whole period recorded by the monuments of geology.

The conclusions here drawn from the facts of physical geology are in perfect unison with the chronological indications afforded by fossils. Beds many feet in thickness, composed of the remains of marine animals, their shells unbroken and undisturbed, and sometimes covered with parasitic growths (just like recent dead shells which remain long undisturbed at the bottom of the ocean) are constantly met with. Here and there are thick strata, composed of nothing but the remains of microscopic plants and animals, which must have required a vast time for their aggregation; elsewhere, the vestiges of huge coral reefs testify that innumerable generations of their slowly growing fabricators must have lived and died, undisturbed, in one locality; and, in some places, enormous accumulations of the bones of large VERTEBRATA, each individual of which must have required many years to attain its full growth, tell the same tale.

The two great astronomical truths to which the general mind has always found the greatest difficulty in assenting are, first, the doctrine that the seemingly fixed earth moves, while the apparently moving sun stands still; secondly, that the earth is but a particle, and the diameter of the system to which it belongs insignificant, when compared with the vast space which separates one of the greater heavenly bodies from another. Geology presents two corresponding truths, as hard to believe and yet as well founded. The first is, that the seemingly fixed land is subject to incessant oscillations, while the sea, so mobile on the small scale, remains in reality comparatively unchanged. The other is, that our historical period, even if we include the widest limit to which tradition would carry the records of our race, is but an insignificant portion of the countless ages which have elapsed since the animals, the remains of which are exposed to view in the Lower Silurian cases of this collection, lived and died and were buried, in the oozy bed of the ocean of that period.

We are, therefore, compelled to believe that a general uniformity has prevailed in the operations of physical and vital nature throughout all time of which we have any record; but just as the generally uniform and regular movement of the celestial bodies is quite consistent with minor and subordinate perturbations, so the proved

uniformity of action of the causes in operation in the physical world, by no means excludes the possibility of occasional sudden and immense changes, or "catastrophes," as they have been called; nor does the equally evident general uniformity of plan, predominant throughout the ancient fauna and flora, in any way interfere with very great and important deviations from those which now exist.

The whole series of strata is divided into three great groups, the oldest of which is termed the PALÆOZOIC, or primary; the next in age, the MESOZOIC, or secondary; the youngest, the CAINOZOIC or tertiary. Each of these groups is broken up into smaller divisions, which are termed FORMATIONS.

The formations, again, are frequently subdivided, for convenience sake, into upper, middle and lower groups, each of which is primarily composed of a greater or less number of distinct strata.[1] The number of strata in a group is a matter of unimportance, depending as it does upon accidental physical conditions; but the number of groups in a formation and the limits of the latter, are, or should be, determined by natural characters afforded by the prevalence of characteristic associations of fossils. Formations, therefore, to a certain extent, stand in the same relation to past time as do provinces of geographical distribution to present space; and they are characterized, like geographical provinces, by a fauna or flora more or less peculiar to themselves, and distinct from those of other provinces. Consequently, the palæontologist, who is a sort of "Kobold" or subterranean traveller, meets in his progress from the existing creation to the remains of the most ancient known condition of things—a journey which may be made by walking from case to case in the galleries of this Museum—with a series of changes in the organic population very similar in character to those which, as has been pointed out above, offer themselves to a circumnavigator of our globe, though they are greater in degree.

6. In the natural history collection in the British Museum, a great proportion of the known forms of living beings are gathered together. Let us suppose it possible that any one should acquaint himself with all these forms of animals and plants, so thoroughly, as to be able at once to recognize them, and having done so, let him walk round the galleries of this Museum, commencing with the cainozoic, and ending with the palæozoic formations, comparing, in his progress, the fossil with the recent forms. A careful scrutiny of the most modern, or post-glacial and newer pliocene fossils, would show that the genera of

[1] *See* the Table of Formations at the end of this Section.

animals which lived then were the same as those which now exist, and that even the species of all but the *Mammalia* are identical; but, at the same time, it would be remarked that the entire association of animals, the fauna as a whole—was very different from that now existing in Great Britain. Thus far, then, the visitor might be inclined to ascribe the changes observed to climatal alteration merely, and to suppose that the really extinct species had simply died out, just as the Dodo, and the *Dinornis*, and Steller's Seacow have died out, in modern times. On passing to the older pliocene, or next oldest formation, however, he would find a few genera, and a considerable number of species, quite different from any which he had observed in the British Museum; and this increase of new species and new genera would go on as he passed back to the miocene and the eocene cases, until, in the latter, he would be unable to identify more than a few per cent. of all the numerous species with those with which he was previously acquainted. He would observe this remarkable change to be accompanied by clear indications of a gradual alteration in climate from a colder than the present, to a warmer; the species in the older beds, identifiable with those now living, belong to warmer latitudes than ours, and the new ones are allied to existing tropical forms.

There is every reason to believe, then, that in the eocene period the climate of England was such as is at present found only in the tropics; but the population was not precisely such as now inhabits the tropics. It was very like it in general aspect, but almost entirely different in detail. Here then, is something which cannot be explained by migration and extinction, any more than we can explain the fauna of New Holland by supposing it to be that of Europe modified by like causes. Here is evidence, that an almost complete replacement of the animals constituting the eocene fauna, by others different from them, though capable of living under similar circumstances, has taken place in more recent times.

But if this result comes out clearly, even from an examination of the tertiary strata, it is still more obviously shown by the investigation of the mesozoic fauna. Here all the species, with a few exceptions among the lowest forms of life, are different from those now living. Numerous new generic types make their appearance, and of the 14 or 15 extinct ordinal types which have been admitted four are found, in the mesozoic rocks, among the REPTILIA alone, one in the AMPHIBIA, and one in the BRACHIOPODA; but it is a most remarkable fact that, throughout the rest of the classes of the animal kingdom, no new ordinal type appears in the mesozoic rocks.

The climate would seem to have been more tropical than that which now exists in corresponding latitudes ; but the caution already given, that it is very hazardous to draw conclusions as to climate from assemblages of species entirely distinct from those now living, must not be forgotten.

As we pass the limit between the mesozoic and the palæozoic strata, a change is observed almost as great as that between the cainozoic and mesozoic systems. The great reptiles characteristic of the latter disappear, and fishes of a very peculiar aspect abound in some of the formations. The other extinct ordinal types make their appearance, two among the CRUSTACEA, three among the ECHINODERMATA, two in the BRACHIOPODA, one among the ACTINOZOA ; and those animals which belong to ordinal types at present existing, differ widely in the relative proportions of the different orders from that observed in the existing fauna. As we go lower in the series, the remains of vertebrate animals become more and more scarce, and at last cease to be found ; then the remains of living beings of any kind become more and more scanty, until in the lowest beds in which organic remains have been discovered, we find only CRUSTACEA, PTEROPODA, TRILOBITES, CYSTIDEA, and BRACHIOPODA, the problematical organisms termed *Graptolites*, and indications of annelids and plants.

So far as the evidence before us goes, then, it appears that the population of our globe has undergone a long series of changes, the groups of forms which at first existed being replaced by others, and these by fresh forms, until those which now exist made their appearance ; there is clear evidence of a *successive* change of life. Can any law be discovered governing this succession ? Is it true, that, as many suppose, the change has not only been *successive* but *progressive* ; that the most ancient creatures are the most imperfectly organized, and that their successors exhibit a gradual advance towards greater and greater perfection ? The evidence on this question may be divided into negative and positive. Under the former head we have the unquestionable fact, that hitherto the most highly organized forms of the VERTEBRATA, ANNULOSA, and CEPHALOPODA have been found most abundantly in the cainozoic and mesozoic formations and that they have not yet been discovered in the very oldest rocks. Under the latter, we have the equally unquestionable facts, firstly, that the oldest known forms of life are neither the lowest organized in the animal kingdom, nor even the lowest of their respective classes and orders ; on the contrary, the lowest British fossiliferous strata contain no representatives of either the CŒLENTERATA or the PROTOZOA, the two most simply organized sub-kingdoms of animal life.

Secondly, the earliest forms of life have no real resemblance to embryonic conditions of the animals which have succeeded them; on the contrary, the earliest forms of fishes and of mollusks belong to the most highly organized orders of each class; and among reptiles, some of the earlier forms appear to have been as highly organized as those which succeed them.

Thirdly, it is certain that many animals and plants have retained the same type of structure through enormous periods. There are Carboniferous plants which appear to be generically identical with some now living; the cone of the Oolitic *Araucaria* is hardly distinguishable from that of an existing species; a true *Pinus* appears in the Purbecks and a *Juglans* in the Chalk; and from the Bagshot Sands, a *Banksia*, the wood of which is not distinguishable from that of species now living in Australia has been obtained. The tabulate corals of the Silurian rocks are wonderfully like those which now exist; and even the families of the Aporosa are all represented in the older mesozoic rocks.

Among the MOLLUSCA, *Avicula*, *Mytilus*, *Chiton*, *Natica*, *Patella*, *Trochus*, *Discina*, *Orbicula*, *Lingula*, *Rhynchonella*, and *Nautilus*, all of which are existing *genera*, are also Silurian; while the highest forms of the highest Cephalopods are represented in the Lias by a genus, *Belemnoteuthis*, which presents the closest relation to the existing *Loligo*.

The two highest groups of the ANNULOSA, INSECTA, and ARACHNIDA, are represented in the coal, either by existing genera, or by forms differing from existing genera in quite minor peculiarities.

Among the VERTEBRATA, the only palæozoic Elasmobranch fish of which we have any complete knowledge is the Devonian and Carboniferous *Pleuracanthus*, which differs no more from existing sharks than these do from one another.

Again, vast as is the number of undoubtedly Ganoid fossil fishes, and great as is their range in time, a large mass of evidence has recently been adduced to show that almost all those respecting which we possess sufficient information are referrible to the same subordinal groups as the existing *Lepidosteus*, *Polypterus*, and Sturgeon; and that a singular relation obtains between the older and the younger fishes; the former, the Devonian Ganoids, being almost all members of the same sub-order as *Polypterus*, while the mesozoic Ganoids are almost all similarly allied to *Lepidosteus*.

The Pycnodonts persist, with but insignificant modifications, from the carboniferous to the tertiary rocks inclusive; the true Cœlacanths, with still less change, from the carboniferous rocks to the chalk, inclusive.

Among reptiles, the highest living group, that of the *Crocodilia*, is represented at the early part of the Mesozoic epoch by species identical in the essential characters of their organisation with those now living; differing from the latter only in such matters as the form of the articular facets of the vertebral centra, in the extent to which the nasal passages are separated from the cavity of the mouth by bone, and in the proportions of the limbs.

And even as regards the MAMMALIA, the scanty remains of Triassic and Oolitic species afford no foundation for the supposition that the organization of the oldest forms differed nearly so much from some of those which now live, as these differ from one another.

However much, then, the negative evidence may seem, without further consideration, to favour the notion of a progressive development of life from the oldest to the latest periods, such positive evidence as we possess is either opposed to it, or capable of another interpretation; and when we come to consider that not a single part of the earth's surface has been examined with anything like the care that has been bestowed upon the British islands, in which the remains of the higher animals have been discovered far lower than anywhere else; when we remember that not more than two-fifths of the ancient rocks can by any possibility be explored by us under the present relative proportions of land and sea; that of this two-fifths not one fiftieth has yet been carefully examined; and when, in addition to all these considerations, we recollect how greatly the chances are against the preservation of the remains of the highest, invariably terrestrial, forms of life in marine deposits, we may well hesitate before adopting any hypothesis based on negative evidence only.

There may, or there may not, have been a progressive development of animal and vegetable life; but the palæontological evidence before us does not justify the assertion that any proof of such progressive change, if it ever occurred, exists.

TABULAR VIEW OF THE CLASSES AND ORDERS OF THE ANIMAL KINGDOM.—(*See* p. 135).

Sub-kingdom I.—PROTOZOA.

Province I.—ASTOMATA.

Class 1.—GREGARINIDA. Class 2.—RHIZOPODA.* Class 3.—SPONGIDA.*

Province II.—STOMATODA.

Class 1.—INFUSORIA.

Sub-kingdom II.—CŒLENTERATA.

Class I.—HYDROZOA.

Order 1. *Hydridæ.*
2. *Corynidæ.*
3. *Sertularidæ.*
4. *Diphydæ.*
5. *Physophoridæ.*
6. *Lucernaridæ.*

Class II.—ACTINOZOA.

Sub-class.

Zoantharia.

Order 1. *Actinidæ.*
2. *Zoanthidæ.*
3. *Antipathidæ.*
4. *Aporosa.*
5. *Perforata.*
6. *Tabulata* (?).

Alcyonaria.

1. *Beroidæ.*
2. *Alcyonidæ.*
3. *Gorgonidæ.*
4. *Tubiporidæ.*
5. *Rugosa.*

Sub-kingdom III.—MOLLUSCA.

Province I.—MOLLUSCOIDA.

Class 1.—ASCIDIOIDA.

Class 2.—POLYZOA.

Order 1. *Cyclostomata.*
2. *Cheilostomata.*
3. *Ctenostomata.*
4. *Hippocrepia.*
5. *Pedicellinida.*

Class 3.—BRACHIOPODA.

Order 1. *Terebratulidæ.*
2. *Spiriferidæ.*
3. *Rhynchonellidæ.*
4. *Orthidæ.*

Order 5. *Productidæ.*
6. *Craniadæ.*
7. *Discinidæ.*
8. *Lingulidæ.*

Province II.—LAMELLIBRANCHIATA.

Class 1.*—CONCHIFERA.

Province III.—ODONTOPHORA.

Class 1.*—BRANCHIOGASTEROPODA.

Class 2.*—PULMOGASTEROPODA.

Class 4.*—PTEROPODA.

Class 5.—CEPHALOPODA.

Order 1. *Dibranchiata.*
2. *Tetrabranchiata.*

Sub-kingdom IV.—ANNULOSA.

Province I.—ANNULOIDA.

Class 1.—ROTIFERA.

Class 2.—ECHINODERMATA.

Order 1. *Echinidea.*
2. *Ophiuridea.*
3. *Blastoidea.*
4. *Edrioasterida.*
5. *Cystidea.*
6. *Holothuridea.*
7. *Asteridea.*
8. *Crinoidea.*

Class 3.—TURBELLARIA.

Class 4.—ENTOZOA.

* Thoroughly satisfactory ordinal subdivisions of the classes marked * have yet to be made.

Province II.—ANNULATA.

Class I.—ANNELIDA.

Order 1. *Polychæta.*
2. *Oligochæta.*
Order 3. *Discophora.*
4. *Sagittida* (?).

Province III.—ARTICULATA or ARTHROPODA.

Class 1.—CRUSTACEA.

Order 1. *Podophthalmia.*
2. *Stomapoda.*
3. *Branchiopoda.*
4. *Copepoda.*
5. *Ostracoda.*
6. *Cirripedia.*
7. *Pœcilopoda.*
8. *Edriophthalmia.*
9 *Trilobita.*
10. *Eurypterida.*

Class 2.—ARACHNIDA.

Order 1. *Pulmonata.*'
2. *Amphipneusta.*
3. *Trachearia.*
4. *Pycnogonida.*
5. *Tardigrada* (?).

Class 3.—MYRIAPODA.

Order 1. *Chilognatha.*
2. *Chilopoda.*

Class 4.—INSECTA.

Order 1. *Coleoptera.*
2. *Orthoptera.*
3. *Neuroptera.*
4. *Hemiptera.*
5. *Diptera.*
6. *Lepidoptera.*
7. *Hymenoptera.*
8. *Strepsiptera.*
9. *Aptera.*

Sub-kingdom V.—VERTEBRATA.

Province I.—ICHTHYOPSIDA.

Class I.—PISCES.

Order 1. *Pharyngobranchii.*
2. *Marsipobranchii.*
3. *Teleostei.*
4. *Ganoidei.*
5. *Elasmobranchii.*
6. *Dipnoi.*

Class 2.—AMPHIBIA.

Order 1. *Batrachia.*
2. *Saurobatrachia.*
3. *Ophiomorpha.*
4. *Labyrinthodonta.*

Province II.—SAUROPSIDA.

Class 1.—REPTILIA.

Order 1. *Chelonia.*
2. *Ophidia.*
3. *Lacertilia.*
4. *Crocodilia.*
5. *Pterosauria.*
6. *Plesiosauria.*
7. *Ichthyosauria.*

Class 2.—AVES.

Order 1. *Raptores.*
2. *Scansores.*
3. *Passeres.*
4. *Columbæ.*
5. *Gallinæ.*
6. *Cursores.*
7. *Grallæ.*
8. *Palmipedes.*

Province III.—MASTOZOA.

Class I.—MAMMALIA.

Sub-Class.—PLACENTALIA.

Order 1. *Primates.*
2. *Cheiroptera.*
3. *Insectivora.*
4. *Rodentia.*
5. *Carnivora.*
6. *Proboscidea.*
7. *Perissodactyla.*
8. *Artiodactyla.*
9. *Sirenia.*
10. *Cetacea.*
11. *Edentata.*

Sub-Class.—IMPLACENTALIA.

Order 1. *Marsupialia.*
2. *Monotremata.*

*** No members of the classes GREGARINIDA, STOMATODA, ASCIDIOIDA, ROTIFERA, TURBELLARIA, or ENTOZOA, have been, or are likely ever to be, found fossil: their orders, herefore, are not given.

TABULAR VIEW of the WHOLE SERIES of AQUEOUS and FOSSILIFEROUS ROCKS.—(*See* p. 171.)

CAINOZOIC, or TERTIARY.		RECENT AND POST-GLACIAL BEDS		BLOWN SAND.—PEAT.
			Fresh-water	*Lake Deposits.* *Old River Alluvium* (*Bric Earth*) (*Warp*). *Clay and Sand of Humber.* *Old River Gravel.*
			Marine	*Shingle.* *Recent Marine* (*Burtle Beds*) *Cave Deposits.* *Raised Beaches.*
		PLIOCENE	Newer	*Sand, Gravel, and Brick Clay* (*Eskers*). *Upper Erratic Boulder Beds.* *Lower Boulder Beds* (*Till*). *Grays, Copford, and Brent ford Beds.*
			Older	*Cave Deposits.* *Norwich Crag.* *Red Crag.* *Coralline Crag.*
		MIOCENE?		*Bovey and Isle of Mull Bed with Vegetable Remains.*
		EOCENE	Upper	*Hempstead Beds (Isle of Wight)* *Bembridge Beds* *Headon, St. Helen's, and Osborne Beds.* — *Fluvio Marin*
			Middle	*Upper Bagshot Sands.* *Barton Clay.* *Brackleshaw Sands.* — *Middl Bagsh* *Lower Bagshot Beds.*
			Lower	*London Clay.* *Woolwich and Reading Beds* *Thanet Beds.*
MESOZOIC, or SECONDARY.	UPPER MESOZOIC.	CRETACEOUS	Upper	*Upper Chalk.* *Lower Chalk.* *Chalk Marl.* *Chloritic Marl.* *Upper Greensand.* *Gault*
			Lower	*Lower Greensand.* *Weald Clay.* *Hastings Sands and Clays.*
			Upper	*Upper*, *Middle*, *Lower* — *Purbeck Beds.* *Portland Stone.* *Portland Sand.* *Kimmeridge Clay.*
			Middle	*Upper Calcareous Grit.* *Coral Rag.* *Lower Calcareous Grit.* *Oxford Clay.* *Kellaways Rock.*

MESOZOIC, or SECONDARY.	LOWER MESOZOIC.	OOLITIC	Lower	*Cornbrash.* *Forest Marble.* *Bradford Clay.* *Great or Bath Oolite.* *Stonesfield Slate.* *Fullers' Earth.* *Inferior Oolite.* *Upper Lias Sands.* *Upper Lias Clay.* *Middle Lias.—Marlstone.* *Lower Lias Clay and Limestone.*
				Penarth Beds (Rhætic).
		TRIASSIC		*Keuper.* *Dolomitic Conglomerate.* *Bunter.*
PALÆOZOIC, or PRIMARY.	UPPER PALÆOZOIC.	PERMIAN		*Magnesian Limestone.* *Lower Red Sandstones and Marls.*
		CARBONIFEROUS		*Upper Coal Measures.* *Middle Coal Measures.* *Lower Coal Measures.* *Millstone Grit.* *Carboniferous Limestone.* *Lower Limestone Shales.*
		OLD RED SANDSTONE AND DEVONIAN		*Upper* / *Middle* / *Lower* *Devonian.*
	LOWER PALÆOZOIC.	SILURIAN	Upper	*Tilestones.* *Upper Ludlow Beds.* *Aymestry Limestone.* *Lower Ludlow Beds.* *Wenlock Limestone.* *Wenlock Shale, with Sandstone and Flags.* *Woolhope Limestone and Shale.* *Denbighshire Grits.* *Tarannon, or Pale Slates.* *Upper Llandovery Rock, or May Hill Sandstone.*
			Lower	*Lower Llandovery Rock, Conglomerates, Sandstones, Shales.* *Caradoc or Bala Sandstone, with Bala Limestone.* *Llandeilo Flags and Limestones.* *Graptolite Shales and Slates.* *Tremadoc Slates.* *Lingula Beds.*
		CAMBRIAN		*Harlech, Llanberris, St. David's, and Longmynd, Grits and Conglomerates with Pale and Green Slates.*
		LAURENTIAN		*Fundamental Gneiss of the Lewis, &c.*

VIII

ON A COLLECTION OF FOSSIL VERTEBRATA, FROM THE JARROW COLLIERY, COUNTY OF KILKENNY IRELAND.

The Transactions of the Royal Irish Academy, 1871, *vol. xxiv. pp.* 351–369.
(*Read January 8th*, 1866.)

THE Coal-producing portions of the counties of Kilkenny, Queen's County, and county of Carlow, have been described more than half a century ago by Sir Richard Griffith, Bart., under the name of "The Leinster Coal District." The general appearance of the Coal country, when viewed from a distance, is that of a very steep ridge of high land, running in a direct line for many miles, rising from 800 to 1000 feet above its base, and apparently flat on the summit. It preserves this character on every side; but when viewed from the eminence itself, it resembles a great barren table-land, rising precipitately above a flat and highly cultivated country.[1]

The portion of this district with which we are more immediately concerned is the high table-land of Castlecomer, which is about 1000 feet over the sea level. The whole of this table-land is formed of a series of dark, sometimes black shales, interstratified with sandstones and flagstones of various shades of grey, which series, from its occasionally containing beds of Coal, is spoken of collectively as "The Coal Measures."

The Coal Measures of this district have a more or less basin-shaped arrangement, resting on the Upper Limestone, beneath which is the Calp, or Middle Limestone, and then the Lower Limestone resting on the Granite. The depth of the Limestone in the centre of the district is about 1,850 feet, or more than 1,000 feet below the

[1] *Vide* "Report on the Leinster Coal District," by Richard Griffith, Dublin, 1814, p. 2.

level of the sea, while on the outer slopes of the table-land it rises to an elevation of some 250 feet above the sea level.

The black shales generally contain Fossils belonging to such genera as *Aviculopecten*, *Euomphalus*, *Goniatites*, *Bellerophon*, &c.; but the beds interstratified with the Coal are found to contain Plants belonging to *Lepidodendron*, *Calamites*, *Sigillaria*, *Pecopteris*, *Sphenopteris*, &c., &c. Several new species of these latter genera, as well as two new species of the genus *Bellinurus*, have been lately described by Mr. W. H. Baily,[1] from the Coal of this district.

In one of these collieries, that of Jarrow, the Coal is worked at a depth of about 210 feet beneath the surface. The roof of the pit is formed of clay slate, immediately under which is a seam of inferior Coal, about three inches in thickness. Then we find a seam of excellent Coal, about three feet in thickness, known as Stone Coal, which rests on a bad description of a foliated Coal, some fourteen inches in depth. Next is a layer of slaty Coal, nine inches in thickness, called by the miners the "wire sole"; then a four-inch Coal, under which is a white-coloured slate rock, and a six-inch bed of culm, resting on the "Coal seat."

The date of the first boring in this pit is 1812. It was first worked successfully in 1827, and continued open until 1832, after which it was not worked until 1853, when it came into the possession of its present proprietor, Mr. S. Bradley. There is some difficulty, from want of positive evidence, in deciding exactly what Coal bed is the one worked in this pit; but no Fossil forms, save those of Ferns, had been detected in it, or in the culm, until Mr. W. B. Brownrigg, visiting the pit late in the season of 1864, was struck by the remarkable appearance presented by some of the tail vertebræ of a Labyrinthodont Amphibian, named in this paper *Urocordylus Wandesfordii*. Believing it to be of the greatest interest, he collected all the specimens of Fossils to be found at the time; and, in the course of the following year, having mentioned the subject to one of the authors of this paper, a grant of money was obtained, in September, 1865, to work the deposit, from the British Association. Since then, repeated visits have been paid to the colliery, the proprietor of which, and Mr. K. Dobbs, the agent of the property, not only giving every facility for the prosecution of these researches, but aiding and assisting in every possible way, in addition to giving the strictest injunction that every specimen found should be properly preserved.

By such systematic collecting a large series of Fossils were very

[1] *Vide* Explanation of Sheet 137 of the Maps of the Geological Survey of Ireland, p. 14.

soon brought to light. Perhaps the largest number of specimens were those belonging to many genera of plants, some of which, in all probability, will throw much light on existing genera of Coal plants, and others may eventually prove to be undescribed species. There is also a considerable collection of Fish remains; spines apparently referable to several species of *Gyracanthus*, with several other Elasmobranchs; large specimens, with the singular vertebral column wonderfully preserved, of some species of *Megalichthys*. Another ganoid fish, upwards of four feet in length, and especially provided with strong, long, and much curved ribs, a broad head, and rounded snout, large opercula, characterized by a raised longitudinal rib, we refer to a new genus, *Campylopleuron*. A still larger fish, also probably undescribed, and about six feet in length, may be referred to the same group. Of invertebrate remains, few have been as yet discovered. Several specimens of *Bellinurus arcuatus*, the clypeus of some unknown Scarabœid insect, and the expanded wing of some large Neuropteron being all that demand any particular notice. Next, however, in number to the Fish remains, and more striking on account of the extreme novelty of the forms discovered, were the Reptilian remains, which it is the object of this communication the more particularly to describe.

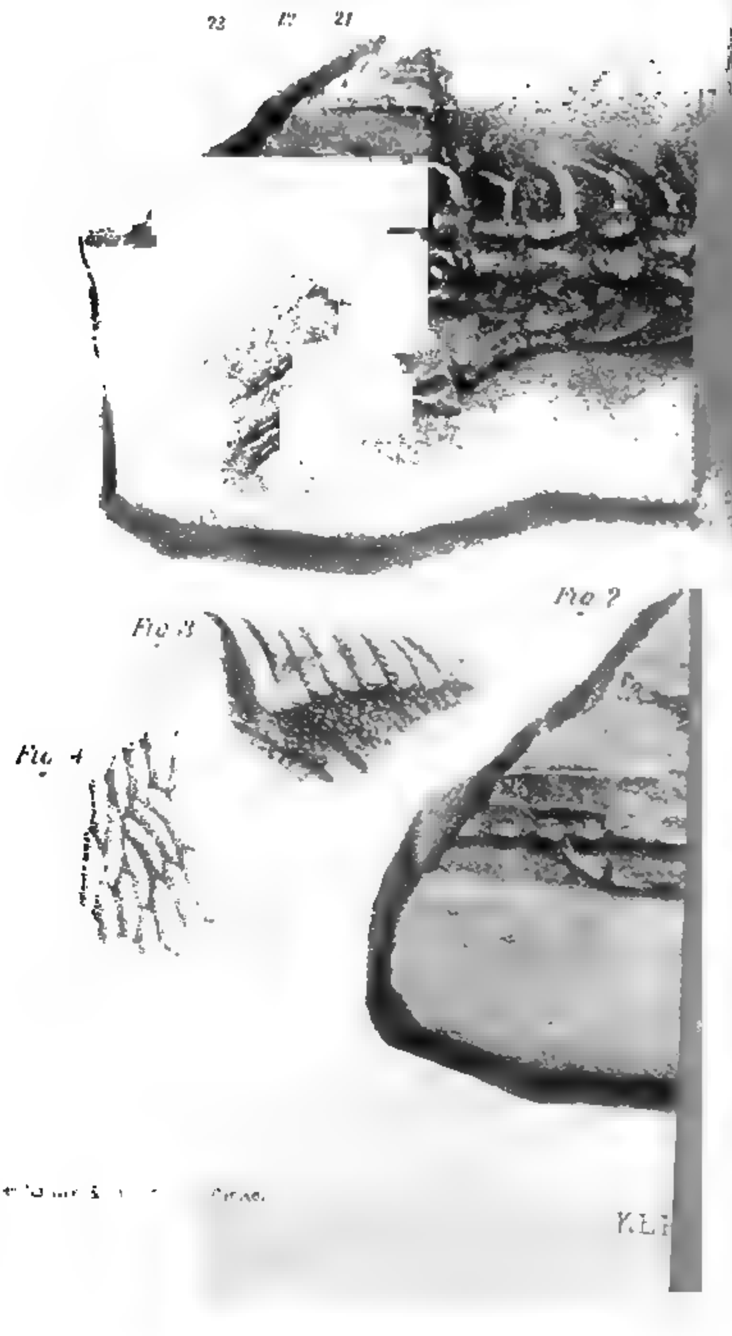
E. P. W.

Description of the Vertebrate Remains from the Jarrow Colliery.

PART I.

In the following pages I purpose to give a description of the characters of only so many of the species of Labyrinthodont *Amphibia* discovered in the Kilkenny Coal field as are figured in the accompanying five Plates. The figures have been executed by Mr. Dinkel, under my own inspection, and are perfectly trustworthy representations of all the well-defined features of the specimens.

Fossilization, however, has taken place in such a manner, that the apparently well-preserved skeletons are really little but bituminous matter, replacing the proper substance of the bone, or rendering it undistinguishable from the surrounding matrix. Hence the specimens resemble casts in soft wax, which look their best at a distance, and rather lose than gain in clearness by close inspection; and those who only see the Plates may be disposed to imagine that the originals are competent to afford much more information respecting anatomical details, than is to be found below. On the other hand, those who compare the Plates with the originals may here and there (though


23
22
21
Fig 2
Fig 3
Fig 4
F.L.F

ınd never in any matter of essential importance), a reading of the forms different from that adopted twithstanding the great care and diligence which he drawings.

c and specific forms described in the present paper

.PETON GALVANI. (Plate XIX. [Plate 17].)
YLUS WANDESFORDII. (Plate XX. [Plate 18].)
ETON DOBBSII. (Plate XXI. [Plate 19], Figs.

PETON BROWNRIGGII. (Plate XXII. [Plate

SOMA EMERSONI. (Plate XXI. [Plate 19]

RPETON BRADLEYÆ (Plate XXIII. [Plate 21],

EPHALUS RUGOSUS. (Plate XXIII. [Plate 21],

ce with KERATERPETON, because its organization illustrated than that of any of the other genera.

I GALVANI. Huxley. (Plate XIX. [Plate 17], Figs. 1–4.)

specimens of this Amphibian in the collection, ıead and trunk in a more or less complete state of nly one of them possesses the hinder two-thirds example the head and anterior vertebræ are somed about an inch of the extreme tip of the tail ıt, so that the length of the entire body cannot be rfect accuracy; but it is safe to assume that it did ıes.

ngth of the skull, from the snout to the middle of pices of the two occipital cornua, is about one inch een one-sixth and one-seventh of the length of the

f the other specimens does the skull equal this presented in Plate XIX. [Plate 17], Fig. 1, it is and in that represented in Fig. 2 of the same Plate, ne inch, so that the latter specimen, probably, did ıches in total length.

Keraterpeton is provided with two pair of limbs, of which the anterior are somewhat shorter than the posterior. The latter are not quite so long as the skull, measured in the way defined above.

The *manus* and the *pes* seem to be rather longer than the rest of the fore or hind limbs taken together, and the digits are slender, elongated, and taper to their extremities.

The dorsal surface of the body is naked, but, on the ventral face the pectoral plates characteristic of Labyrinthodonts are visible; and behind these, and in front of the posterior limbs, the belly is thickly covered with a sort of scale armour, consisting of minute and close-set scutes.

The extreme breadth of the skull (seen from above in Fig. 1, from below in Fig. 2), from tip to tip of its postero-external cornua, is about equal to its extreme length, from the tip of the snout to a line joining the apices of its postero-internal cornua; but this great relative breadth may arise, to some extent, from the flattening of the specimen.

In form the skull resembles an unequal-sided hexagon, four of the angles of which are produced into the postero-external and postero-internal cornua. These last take up about two-sevenths of the extreme length of the skull, and are pointed and curved, so as to be slightly convex outwards; their surfaces are rounded from side to side, and longitudinally striated. The line of the occiput between their bases is straight, or slightly concave backwards.

The postero-external cornua are not more than half as long as the preceding, and do not show any distinct signs of striation.

The orbits are large and oval; their long axes being parallel with one another, and with that of the skull. They are separated by an interorbital space, equal to about the transverse diameter of one of them. They are removed from the anterior end of the snout by about the same distance, and lie almost wholly in the anterior half of the roof of the skull.

In the middle line of the posterior moiety of this roof, and rather nearer the orbit than the occiput, there is a slight depression, indicating the existence of a parietal foramen (Plate XIX. [Plate 17] Fig. 1).

What I believe to be the under surface of the roof of the skull is shown in Fig. 2, and exhibits a well-marked depression in the middle line, on a level with the posterior boundaries of the orbits, which may well represent the inner end of a parietal foramen.

If this interpretation be correct, the basis cranii is wanting, as well as the palatine and pterygoid bones. It is quite possible, how-

ever, to interpret the appearances in another way—to regard what appear to be the orbits, in this view, as the palatine foramina, and to consider this median depression to be caused by the divergence of the pterygoid bones; nor does the state of the specimen permit a decisive verdict to be given in favour of either of these interpretations.

The lower jaw has slender and arcuated rami, which appear to have remained separate at the symphysis. Indications of minute, close-set and pointed teeth are visible in both the specimens figured, and in others.

In the specimen represented in Fig. 2, oblique linear elevations, which appear to have been produced by the hyoidean apparatus, are visible on each side, between the skull and the pectoral plates. However, these markings are very obscure. No sutures can be made out upon the surface of the skull, nor are there any very clear traces of superficial sculpturing, except those on the postero-internal cornua, and on the angular part of the lower jaw. The occipital condyles are not certainly discernible in any of the specimens.

In the specimen represented in Fig. 1, twenty-three vertebræ occupy the space between the posterior edge of the occiput and the fractured edge of the slab. The two hindermost vertebræ (22 and 23, Fig. 1) are devoid of ribs, and show very plainly the broad, wedge-shaped subvertebral bones, which are anchylosed to the middle of their centra. In the antipenultimate vertebræ (21) traces of a similar subvertebral bone can be discovered in certain lights, though they are not very distinct. No subvertebral bone appears in connection with the twentieth vertebra, but a short, curved rib lies on each side of it. I suppose, therefore, that *Keraterpeton* had twenty vertebræ in the place of those which are called cervical, dorsal, lumbar, and sacral in higher Vertebrata. Twelve pair of ribs can be distinctly counted between the pectoral and the pelvic limbs. They are stout, and strongly curved, with distinct tubercula and capitula. The anterior ribs are rather larger than the posterior ones, and are equal to about three of the vertebræ in length. Their ventral ends are rounded, and no traces of sternal ribs are anywhere visible. The ribs behind the posterior limbs (in their present position) are shorter than the others. Such as exist in front of the fore limb are indistinct in the specimen Fig. 1, while, in Fig. 2, the pectoral plates cover them; nor are they well shown in any of the other specimens.

It is probable, however, that all the vertebræ between the occiput and the first caudal (21) bore ribs; and I shall speak of them, for brevity's sake, under the general title of *dorsal* vertebræ.

These vertebræ are of tolerably equal length throughout, and have elongated centra, slightly constricted in the middle. The form of the articular ends of the centra cannot be ascertained ; but they were, probably, deeply excavated. The vertical height of each vertebra is about equal to one and a half times its length. The arches of the vertebræ and their spines have the same antero-posterior extent as the centra themselves. The edges of the spines are abruptly truncated, and minutely serrated or notched, the notches representing the ends of striæ which mark the face of the spine. There are distinct anterior and posterior oblique processes, or zygapophyses.

The twenty dorsal vertebræ of Fig. 1 occupy a space of 2·75 inches, which gives 0·137 inch for each vertebra. The largest vertebræ in the collection, which are referrible to this genus, are 0·22 inch long, answering to a length of less than a foot for the whole animal.

The specimen in which the tail is most completely preserved exhibits three vertebræ, provided with short, curved ribs, between the level of the proximal end of the femur and the first vertebra, which is provided with a subvertebral bone, or first caudal vertebra. Succeeding this are seventeen vertebræ, remarkable, like the first caudal, for the close similarity between their spinous processes and their subvertebral bones.

The terminal vertebra of this continuous series of eighteen is 0·15 inch long, and 0·2 inch high, whilst the first caudal is 0·2 inch long and 0·37 inch high, including the subvertebral bone. The entire series of vertebræ is 3·6 inches long ; but probably a full inch of the tail, containing six or seven of the vertebræ, is wanting.

The pectoral arch presents two large scapulæ (?), broad and squamiform at their glenoidal ends, but produced backwards and upwards into strong, spine-like prolongations at their opposite extremities (Fig. 1). In the specimen represented in Fig. 2, a flat rounded bone, apparently representing a coracoid, is seen at the proximal end of the right fore limb.

In Fig. 2 (and in the specimen here figured alone) are further seen the sculptured pectoral plates (*a*) which are so highly characteristic of Labyrinthodonts. There are three of these plates—one in the middle, and one on each side, but the plates are pushed out of place and distorted. Hence it is, I suppose, that the middle plate does not exhibit the rhomboidal, and the lateral plates the triangular form usually seen ; but there can be no doubt as to the general correspondence of these plates with the pectoral plates of Labyrinthodonts.

Part of a ventral shield, which was, I doubt not, as in *Archegosaurus* and *Pholidogaster*, continuous from the pectoral plates to the

elvis, is displayed in Fig. 2; the ends of the posterior ribs project eyond its margins. It appears to be composed of minute scales, ıch as are represented in Fig. 4, much magnified; and at the margins f the anterior part of the shield these minute scales are fringed by ırger ones, as in the less magnified Fig. 3. Though the shield itself plain enough, its components vary in appearance according to light nd magnifying power, and it is very difficult to arrive at any safe pinion regarding their exact character.

The humerus is not distinctly shown by any specimen. The ıdius and ulna (Plate XIX. [Plate 17], Fig. 2) are bones of nearly qual length and thickness, and are constricted in the middle, and road at their ends. The carpus is not ossified. There are five ıetacarpal bones (the two largest of which are displaced in Fig. 2), nd as many digits, the greatest number of phalanges in any digit eing four. The terminal phalanges are very small, and were robably devoid of horny claws.

By no specimen are the pelvic bones shown. The femur (Fig. 1) short and stout, and less constricted in the middle than the bones f the leg, which it exceeds in length by nearly a third. The tibia nd fibula are about equal in length, but the tibia is the stouter bone. oth these bones are very similar in form to the corresponding bones f the fore limb.

The components of the tarsus are not represented, and were oubtless unossified. There are five digits, the metatarsal bones of hich are strong, and have remarkably well-defined articular ex-emities.

The hallux is provided with only two short phalanges, and not more than half as long as the second toe, which, like the thers, has three phalanges. The second, third, and fourth toes are ıbequal.[1]

The fifth digit is rather shorter than the second. The distal halanges of all these digits are slender and tapering, and probably ıpported no claws.

The specimen figured in Plate XIX. [Plate 17], Fig. 1, is that pon which the genus was founded, and is the first of these Irish arboniferous *Amphibia* with which I became acquainted, as it was rought under my notice by my friend and colleague, Professor ukes, in November, 1865. It was then named by me, after Mr. alvan, by whom the specimen was obtained; and the exist-ıce of Labyrinthodonts in the Coal fields of Ireland was thus etermined.

[1] The second and third phalanges of the fourth are somewhat too long in Fig. 1.

II. UROCORDYLUS WANDESFORDII. Plate XX. [Plate 1
Figs. 1 and 2.

The genus *Urocordylus* is evidently closely allied to *Kerate*
but it is at the same time very obviously differentiated fro
latter by the size and strength of its tail, and especially by the
development of the neural spines and chevron, or subvertebral,
of the caudal vertebræ.

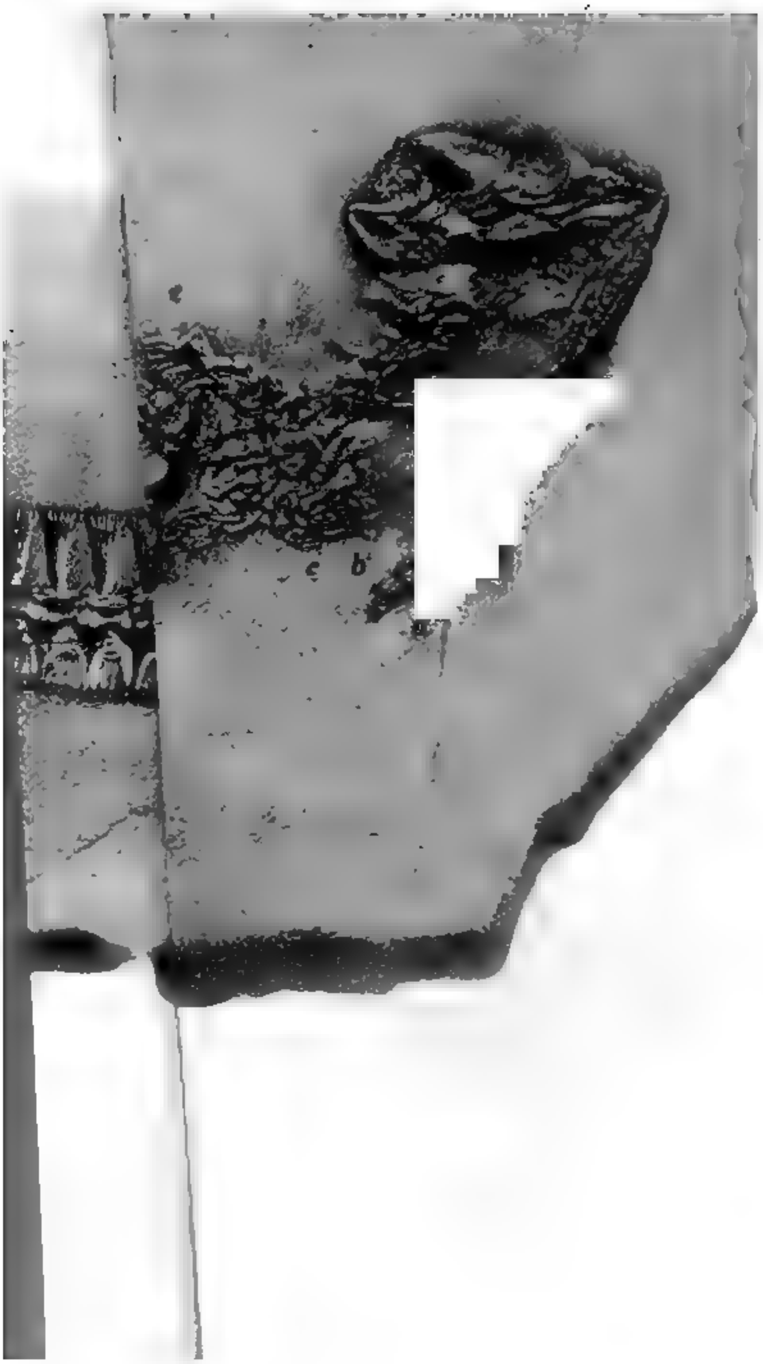
Only one tolerably complete specimen (Plate XX. [Plat
Fig. 1) of this remarkable Amphibian has been obtained; and
in this, the bones of the trunk and limbs are so much distorted
its precise dimensions and proportions cannot be determined
the skeleton lies, it measures 18·5 inches in a straight line from
snout to the extremity of the tail, but the animal was prob
inch longer. From the occiput to the end of the snout, th
could not have exceeded 1·3 inch in length. The corresp
dimensions of the skull in the *Keraterpeton* of 10 inches
length, is 1·1 inch, so that the skull of the latter genus is
twice as large, in proportion to the length of the body, as t
Urocordylus.

The animal is so disposed as to display the ventral surface
head and body, and the right side of the tail. The skull is so
crushed and obscured by the matrix, that only its general for
be made out. In its general proportions, and the form of the
jaw, it much resembles that of *Keraterpeton*, but no indications
remarkable cornua of the latter are observable.

The vertebræ of the trunk lie for the most part upon th
sides, and greatly resemble those of *Keraterpeton*. Those wh
distinctly enough defined to be measurable are 0·2 inch lon
little longer, and 0·35 inch in extreme height, with long and low
like, neural spines, the faces of which are striated and the
serrated, as in *Keraterpeton*.

I can count fifteen vertebræ in front of the great hiatus
series of the trunk vertebræ, and four behind it. Probably, th
there were about twenty dorsal, or precaudal, vertebræ in *Uroc*
as in *Keraterpeton*. The three vertebræ forming the root of t
are disposed at an angle to the four hindermost precaudal ve
and to the other caudal vertebræ, which form a continuous a
broken series.

From the root of the tail to the point marked (*a*) Fig. 1, th
sixty vertebræ; beyond this point there seem to be about
more, but they become very indistinct towards the end.


c
b

The centra of the anterior caudal vertebræ are 0·28 inch long, and the total height of a vertebra from the dorsal edge of the neural spine to the ventral edge of the subvertebral bone is 0·95 inch. The two vertical processes are each 0·35 inch long; the intermediate part, formed by the body and neural arch, measuring 0·25 inch, or as much as the length of the body. The zygapophyses project outwards, as well as backwards and forwards; and a marked longitudinal depression is observable, as in *Keraterpeton*, below the part of the arch from which they spring, and on that which lies between them and the proper centrum.

The neural spines are thinner and, posteriorly, higher, than the subvertebral bones, which are anchylosed, as in *Keraterpeton*, by comparatively narrow necks, with the middle of the ventral faces of their centra; the striæ on their surfaces are more distinct, and their free truncated edges are regularly denticulated.

The anterior thirty-six vertebræ retain very nearly the same height, and differ only by becoming shorter antero-posteriorly; the length of the centra gradually falling to 0·2 inch.

The forty-seventh vertebra is still 0·8 inch high; but from this point the neural spines and subvertebral bones rapidly diminish to the extremity of the tail.

Up to and including the thirty-sixth vertebra, the axes of the neural spines and subvertebral bones coincide, or are parallel, both being vertical to the long axes of the vertebræ; but in the succeeding vertebræ the axes of both incline backwards, and meet at a very obtuse angle.

Up to the forty-second vertebra, the spines and subvertebral bones, though gradually diminishing in antero-posterior extent, retain their strong grooves and striations, and their frayed or notched edges; but further backward they first taper towards their ends, and, finally, assume the characters of ordinary spinous processes.

The ten vertebræ, 51 to 60 inclusive, occupy only an inch, or have on the average, less than half the length of those at the root of the tail.

Traces of numerous, short, curved and stout ribs are visible in the confused mass which occupies the dorsal region of the trunk, and which contains multitudes of oat-shaped scales, 0·2 inch long, which composed the ventral dermal shield.

I can find no pectoral plates in this specimen. The fore limb is represented by a semilunar coracoid (*b*), 0·3 inch long, with one contour semicircular, and the other slightly excavated, and altogether similar to (*b*) in Fig. 2. A humerus (*c*), 0·35 inch long, lies close to

A femur, probably the left, is visible at (f). It is hal
again as the humerus, and a much stouter bone.

The left tibia and fibula (g) are much shorter than the fe
each bone is constricted in the middle, as in *Keraterpeton*.

Unless (l) represents the right femur broken and disto
not see it. The right tibia and fibula are displayed at
digits of the pentadactyle feet at (h) and (h'). The *pes* a
have had the same short hallux and general structure a
Keraterpeton.

The length of the entire hind limb cannot have been les
inch ; and not quite half of this length is occupied by the fe
was 0·4 inch broad in the metatarsal region.

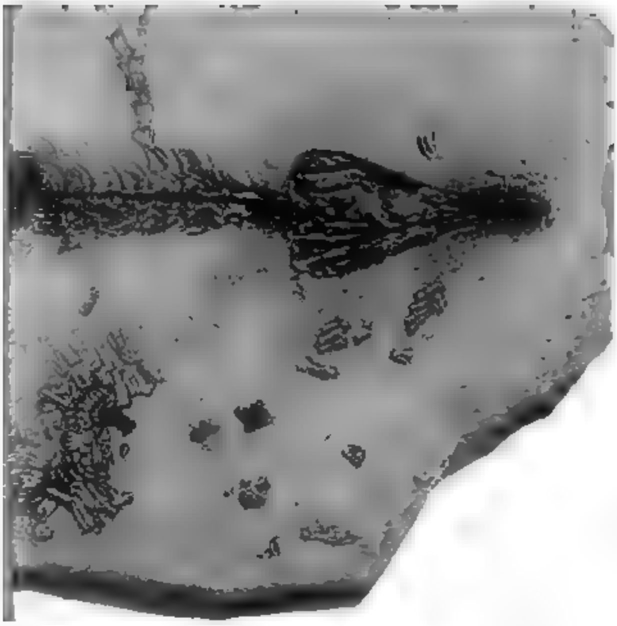
The fore limb had probably two-thirds the length of the h

The two bones marked (i) and (k) appear to be par
pelvis.

Fig. 2, in Plate XX. [Plate 18], represents bones from
parts of another slab, presenting the greatly disturbed ske
much smaller and younger *Urocordylus*, the anterior caudal
of which are only 0·5 inch high ; so that its length was prob
more than half that of the specimen from which the fore
scription is taken. These bones are represented half as la
as the natural size. At (b) is a detached coracoid, with a
(c); at (c') is the other humerus, lying across a rib ; anoth
shows the distinct capitulum and tuberculum of the verte
the broad sternal end, and the curvature of the rib itself. (
I take to be the two lateral pectoral plates, and (d) the rh
median one. At (f) the impression left by the hinde
ossicles of the ventral armour is represented, showing that t
disposed as in *Pholidogaster* and *Archegosaurus*.

This species of *Urocordylus* is named after the lord of t

Plate XXI



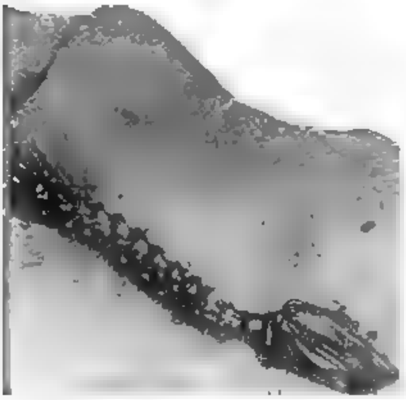


Fig d

counterpart of the same slab showing part of the skull; and a second crushed and imperfect example.

The total length of the skeleton, which has undergone very little disturbance, is as nearly as possible 6·0 inches. The length of the head, from the end of the snout to the occiput, is 0·85 inch, or one-seventh of that of the whole body; from the occiput to the last rib-bearing vertebræ is 2·0 inches; the tail makes up the other three inches and a fraction, and is rather longer than the head and trunk together.

The fore limb is a little more than half an inch long; the hind limb, 0·85 inch long, and much stouter; the *pes* and *manus* are longer than the other parts of their respective limbs taken together.

The number of dorsal, or precaudal, rib-bearing vertebræ is either twenty, or within one on either side of that number.

The impressions left by the centra show them to have been hourglass-shaped; and, in the second specimen, their spinous processes are seen to be low ridges, extending along the whole length of the middle of the arch of the vertebræ (Plate XXI. [Plate 19], Fig. 2).

The ribs are short and curved; and three pair, shorter than the others, lie behind the level of a transverse line, joining the heads of the femora. Between the ribs delicate confused markings are seen, which I suppose to arise from the ventral dermal armour.

I observe no impressions of ribs in connection with the two anterior vertebræ.

There are about twenty-five caudal vertebræ, with hourglass-shaped centra, and long low spines. Their impressions of the sub-vertebral bones are not distinct.

The centra of the vertebræ in the trunk are about 0·1 inch long; they are rather longer in the anterior part of the tail.

The skull differs very much in form from that of either of the preceding genera, not only in being much narrower in proportion to its length posteriorly, but in possessing a tapering snout, like that of an Egyptian crocodile on a small scale.

The slender rami of the mandible converge towards one another to the symphysis, where they become parallel, and are united for nearly 0·3 inch. The orbits are over 0·13 inch long, and are situated in the middle of the length of the skull.

There are indications of relatively long, pointed, and slightly curved teeth, set at intervals in the upper jaw.

The hind limb is pentadactyle, and has a small hallux, the other digits (each of which appears to have possessed three phalanges)

being very long and slender; the carpus and the tarsus ar
ossified.

Impressions of what appear to be traces of the pectoral and p
arches are discernible, but I can find no clear indication of the pe
plates.

The fragmentary second specimen appears to have belonged
a nimal about an eighth longer than the example figured.

This species is named after the agent of the property upon w
the specimen was obtained.

IV. Ophiderpeton Brownriggii. Plate XXII. [Plate 20 Figs. 1–4.

The most perfect specimen of this remarkable animal (na
after Mr. Brownrigg, to whom our obligations have already
expressed) is that represented, of the size of nature, in Fig. 1,
XXII. [Plate 20].

From the extremity of the snout to the fractured termin
of the body, the specimen measures about 14·5 inches along its cur
the skull is 0·9 inch long, and the ramus of the lower jaw has
same length.

The cranium is in a very unsatisfactory state of preservation,
all that can be said with certainty is, that the roof of the sku
broad, and has an obtuse and rounded anterior end; the ramu
the mandible is strong, and has a curved lower contour, its artic
end being especially curved up.

Another specimen, exhibiting the impression of the right side
the skull, is represented in Fig. 4; while Fig. 3 gives an under v
of the skull and fore part of the body, with the two rami of
mandible, from another slab. Both these figures are of the nat
size; and it will be observed that the rami of the mandibles are ab
half as long again as that of Fig. 1, indicating that these cr
belonged to larger animals. In Fig. 3, a number of small elevati
greatly resembling teeth, are seen in connection with what appea
be the right maxilla; in Fig. 1 three similar, conical, tooth-
bodies are attached in the right maxillary, or palatine, region (Fig.

Indications of not fewer than fifty vertebræ can be seen succe
ing the head, in a partially interrupted series, in Fig. 1, but not
of these vertebræ is in such a condition that its whole structure
be made out. The vertebra marked (*b*) appears to be about
twentieth from the head; its dorsal surface is turned to the eye,
shows the fractured base of the spinous process, and the diverg

ıterior and posterior zygapophyses; the hourglass shape of the :ntra is observable in the vertebræ which immediately precede this. ther specimens lead me to believe that the spinous processes of the :rtebræ of the *Ophiderpeton* were low, and were much shorter antero-›steriorly than the centra of the vertebræ.

The vertebra (*b*) and its immediate neighbour are 0·28 inch long, ıt towards the head the vertebræ are shorter; towards the fractured ıd, on the other hand, they are fully 0·25 inch long, which is alone ıfficient to indicate that this end is distant from the true posterior ıd of the body.

Evidence of the existence of long and nearly straight ribs is to be ›und in various parts of the specimen, particularly about the points ıarked (*c*) and (*a*) in Fig. 1; but these are obscured by the ventral ıield, which is traceable from close behind the head to the antepen-ıtimate vertebra, as a band, varying from one-quarter, to three-uarters, of an inch in width. It is entirely confined to the ventral de of the vertebral column, and made up of elongated, slightly ırved, ossicles, pointed at each end, and applied side by side in :ries, the direction of which cuts that of the axis of the body bliquely. The largest of these dermal ossicles are about 0·2 inch ›ng, by 0·03 inch thick.

I can discover no trace of either fore or hind limb in this specimen, or in any other which certainly belongs to the same genus.

One slab from the Jarrow Colliery exhibits the remains of an *)phiderpeton* disposed in a continuous wavy line, twenty-one inches ›ng. The length of the middle vertebra in this specimen is the same s that of the corresponding vertebra in Fig. 1, or 0·25 inch. At the inder extremity the vertebræ, though very indistinctly shown, are ecidedly smaller in all dimensions; and Dr. Wright informs me that, 'hen first found, this end of the specimen was terminated by a :curved tail. The head is absent at the anterior end; but I am ıclined to think, from the character of the impression left by the ›remost vertebræ, that they were not far from the head.

The number of the vertebræ in this specimen cannot be ascertained ʳith precision; but it is safe to assume that, when the animal was ntire, they must have approached, or even exceeded, a hundred.

A fragmentary impression shows a head, 1·6 inch long, or twice s large as that of the specimen represented in Fig. 1, with eleven ıches of the anterior end of the vertebral column.

According to the length of the head, this specimen ought to have een twice as long as that represented in Fig. 1; but, as the individual ertebræ are but very little longer, this can only be the case if the

number of the vertebræ increased with age; and it is much more likely that the head should have increased disproportionately to the rest of the body. However, the workmen declare that they have found impressions resembling those of *Ophiderpeton* more than three feet long.

V. Dolichosoma Emersoni. Plate XXI. [Plate 19], Fig. 3.

Another remarkable snake-like, or eel-like, Vertebrate from the Jarrow Colliery, obtained by the Rev. J. M. Emerson, and presented by him to the Dublin University Museum (from which Professor Haughton has kindly permitted me to borrow it), is represented, of nearly twice the natural size, in Plate XXI. [Plate 19], Fig. 3.

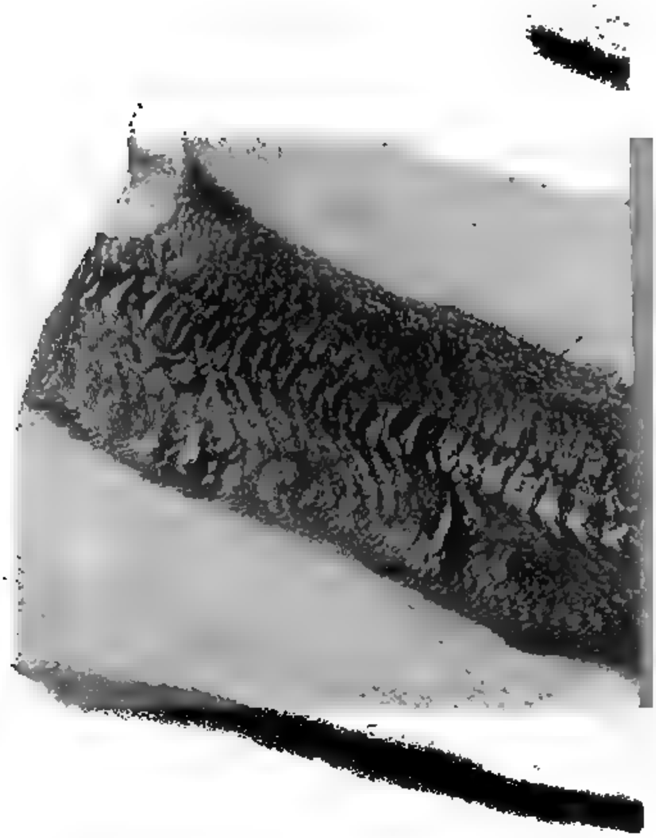
Measured along its curvatures, this fossil is 3·7 inches long; the head having a length of 0·32 inch, and a width, at the occiput, of 0·13 inch. The skull is thus narrow, and tapers from the occiput to the snout, so as to have the form of an isosceles triangle. The lower jaw repeats the form and general dimensions of the head, and has very slender rami.

The vertebræ, of which there are more than forty between the occiput and the point indicated by (*a*), have stout, slightly constricted centra, low spinous processes, and apparently well-developed zygapophyses. The ribs are more slender, straighter, shorter, and taper more rapidly towards their sternal ends, than in the genera already described. They appear to have bifurcated proximal ends, and are hardly longer than the vertebræ. Close to the head ten vertebræ occupy a space of 0·55 inch, or 0·055 inch each. At the opposite extremity, in front of (*a*), the same number take up 0·7 inch, or 0·07 inch each; behind this point (*a*), a more imperfect impression remains, and certainly does not truly represent the entirety of the hinder continuation of the vertebral column.

The form of the head, and more particularly of the lower jaw, precludes the supposition to which I was once inclined, that this might be a young *Ophiderpeton*,

The form of the ribs and vertebræ, as well as of the skull, excludes all approximation to *Lepterpeton*, even were the absence of limbs accidental, which I do not conceive to be the case. The characters of the vertebræ, the absence of opercular and branchial elements, and of median fin rays, determine *Dolichosoma* not to be a fish; and, though it lacks the positive labyrinthodont character of *Ophiderpeton* afforded by the ventral armour, it is, otherwise, so closely analogous to the latter form, that I arrange it therewith.

Fig 2



VI. ICHTHYERPETON BRADLEYÆ. Plate XXIII. [Plate 21], Fig. 1.

Keraterpeton, *Urocordylus*, and *Lepterpeton* exhibit the labyrintho- : type under a salamandroid aspect; in *Ophiderpeton* and *Dolicho-* : it becomes serpentiform; in the present genus (named after the of the proprietor of the colliery, by whose permission the great)rity of the fossils under description have been contributed), it is : pisciform.

The fossil represented in Plate V. [Plate 21], Fig. 1, comprises hinder moiety of the trunk, with the greater part of the tail, of an ıal whose scaly integument and laterally compressed, fin-like, tail ht easily lead one to take it for a fish, were not its true position ng higher *Vertebrata* settled at once by the digitated hind limb; e its alliance with the Labyrinthodonts is indicated by the delicate ular-ossicles, which form a sort of rudimentary dermal shield along belly.

So much of the body as remains would measure fully ten inches ngth, if the tail were complete.

The series of the vertebræ, which appear to have had discoidal ra 0·15 inch long, but considerably deeper, is continuous to beyond level of the hind limb. Further back the caudal vertebræ would ı to have been imperfectly ossified. Traces of short ribs can be rved, in connection with the vertebræ of the trunk.

The appearance of the integument varies a good deal with the t under which it is viewed. At first sight, and especially in the it appears to be covered with true scales; but, on close examina- , many of these scales appear rather to be merely the spaces ked out by minute elevations, ridges, or wrinklings, of the skin itself. The middle of the ventral surface of the trunk presents numerous ute, more or less parallel ridges, pointed at each end, and taking neral course obliquely downwards and forwards to the middle I am strongly disposed to think that these ridges are produced lermal ossicles, like those of *Ophiderpeton*, and other Labyrintho- ts.

The integument extends loosely over the hind limb as far as the atarsus, forming a broad conical projection, whence the digits rude. Indefinite outlines of the bones of the leg can be traced in this projection; and four distinct digits, with three short and k phalanges in each, can be distinguished; the fifth digit is not arent. A number of scattered phalanges, probably belonging to other leg, are seen under the middle of the tail.

VII. Erpetocephalus Rugosus. Plate XXIII. [Plate 21], Fig. 2.

It is not impossible that the skull represented in Plate XXIII. [Plate 21], Fig. 2, may belong to *Ichthyerpeton*, but I have no positive evidence that it does. It certainly has nothing to do with *Keraterpeton*, *Lepterpeton*, *Ophiderpeton*, or *Dolichosoma* ; and its size excludes *Urocordylus*, unless that genus attained very much greater dimensions than there is any reason to believe it reached.

Under these circumstances, I think the safest plan will be to regard it as the type of a new genus and species, which may be called *Erpetocephalus rugosus*.

The skull is somewhat crushed, and the left maxilla has disappeared, together, as I suspect, with the whole or part of the premaxillæ. As it is, it measures 2·5 inches from the centre of the occiput to the end of the snout, and 1·2 inch from the centre of the occiput to the nearest point of the right margin, which would give a maximum breadth of 2·4 inches, or nearly the length of the cranium ; vertical crushing, however, has probably rendered the skull rather broader than it naturally would be.

The epiotic, or postero-internal, prominences of the hinder margin of the skull, are conical ossifications, as in Labyrinthodont Amphibia in general and osseous fishes. Separated from them by a notch are the postero-external (pterotic or squamosal) processes ; but the condition of the specimen renders it doubtful whether these extend only to the level of the epiotics, as the left side of the specimen suggests ; or whether they are prolonged further back, as seems, atfirst sight, to be the case on the right side. It is quite possible, however, that what appears here to be the continuation of the postero-external angle of the skull is really the outer side of a broad quadrate bone, or it may possibly be the angle of the mandible itself.

The cranial bones are covered with irregular, sometimes radiating, rugosities, separating small depressions. No sutures are distinguishable ; but a small pit in the middle line, 0·7 inch in front of the occiput, may represent the parietal foramen. No "mucous grooves," such as are visible on the crania of many Labyrinthodonts, are distinguishable.

The orbits are placed in the middle third of the skull, and are separated by an interorbital space, 0·75 inch wide. The orbit is oval, 0·6 inch long, by 0·45 inch wide, and its outer edge is 0·25 inch distant from the lateral margin of the skull.

The nostrils appear to be situated at the anterior end of the snout ;

but they are obscure, and, in any case, are incomplete externally. The right ramus of the mandible exhibits a number of small sharp-pointed conical teeth, set in a single series. Impressions, which very probably arise from the sculptured surfaces of the pectoral plates, are visible at the posterior edge of the specimen.

NOTE, *Dec. 4th*, 1866.—The collection of fossils forwarded to me contains, still undescribed, the remains of, at fewest, three more genera of *Amphibia*, viz., *Discospondylus*, *n. g.*, *Brachyscelis*, *n. g.*, and a large Amphibian, closely allied to, if not identical with, the *Anthracosaurus* of the Scotch Coal field, besides the singular fish, *Campylopleuron.*

[*Note, added Dec. 14th*, 1866.—I consider it right to mention that Mr. W. B. Brownrigg has given a brief account of the discovery of some of the fossil remains described in this paper, in the "Journal of the Royal Geological Society of Ireland" (vol. i., part 2, p. 145). Mr. Brownrigg's notice was read on the 15th of June, 1865, but no attempt is made therein to describe the specimens that were exhibited. It was at Mr. Brownrigg's suggestion that the name "Wandesfordii" was given to the only species discovered of the genus Urocordylus. The specimens from which Mr. Dinkel has made the drawings which accompany this paper will, with the exception of Fig. 1, Plate XIX. [Plate 17], be presented, I am informed, by Mr. Brownrigg, to the Geological Museum of the University of Dublin. At a visit made to Jarrow, on the 11th of October last, I saw a collection of specimens made during the summer for Mr. Brownrigg, which, besides many specimens of the above-described species, also contained several apparently new genera of Reptiles and Fish.—E. P. W.]

NOTE BY THE EDITOR OF THE SCIENTIFIC MEMOIRS.

[The introduction to the above paper, signed with the initials E. P. W., is by Prof. Perceval Wright, of Trinity College, Dublin. In the "Geological Magazine," Vol. III., 1866, appears an abstract of the paper, which was subsequently printed in full in the "Transactions of the Royal Irish Academy," and is here reprinted as there published. The abstract bore the title, "On a Collection of Fossils from the Jarrow Colliery, Kilkenny, Ireland, by E. Perceval Wright, M.D., F.L.S., Professor of Zoology, Dublin University. With a Description of the Vertebrate Remains, by T. H. Huxley, F.R.S., Professor of Natural History at the Royal School of Mines, Jermyn Street." In the paper as published in full by the Royal Irish Academy, Prof. Perceval Wright's name is withdrawn, and his share in the paper is indicated by the placing of his initials (p. 182) at the end of the historical and topographical introduction.—E. R. L.]

IX

ON SOME REMAINS OF LARGE DINOSAURIAN REPTILES FROM THE STORMBERG MOUNTAINS, SOUTH AFRICA.

Quarterly Journal of the Geological Society of London, vol. xxiii., 1867, *pp.* 1–6. (*Read November 7th*, 1866.)

IN a box of fossils sent to Sir R. I. Murchison, Bart., by Mr. Alfred Brown of Aliwal North, South Africa, and submitted to me for examination and determination, I found certain fragmentary large reptilian bones, to which a very considerable interest attaches.

The most important of these are two femora, a right and a left. The articular ends of both of these bones are wanting; and the shaft of the left is far less complete than that of the right, to which the following remarks more particularly apply.

It is broken into four pieces; but these, when carefully fitted together, have a total length of 25·5 inches; and it may be safely assumed that the length of the entire femur exceeded 30 inches, as its distal extremity is only beginning to widen for the condyles. At 20·5 inches from the proximal end, the transverse diameter of the shaft is 5·1 inches, the antero-posterior diameter 4·2 inches. The contour of the transverse section at this point is a transversely elongated oval, the posterior face being so much more flattened than the anterior as to make it almost semilunar.

Viewed sideways, the shaft of the bone is, for the greater part of its length, nearly straight, though its dorsal contour is a little convex. But towards the proximal end it becomes widened and flattened from above downwards, while, at the same time, its longitudinal contour becomes concave above and convex below.

In its dorsal, or upper, aspect also, the greater part of the length of the shaft of the bone is nearly straight; but at nine inches from

the proximal end it curves so as to have a convex outer and a concave inner contour. The latter curve takes a broad and gradual sweep. In consequence of the various curvatures and other changes of form which have been described, the broad and flattened proximal end of the femur is, as it were, twisted upon the more cylindroid shaft, the long axis of its section forming an acute angle with that of the shaft.

The outer surface of the greater part of the shaft of the bone is somewhat flattened. Just where the proximal end begins to bend inwards, the junction of the outer and the upper faces rises into an obtuse ridge, nowhere more than an inch broad and as much high, which is continued for about four inches upon the outer or convex edge of the incurved proximal part of the bone, and ends, in an obtuse summit, at 5·75 inches from the proximal end.

The surface of this outer trochanteric ridge is unbroken very nearly to its proximal end; so that if it were ever continued into a free process, this must have been comparatively short and slender.

From its inner and under side the shaft of the femur gives off a very stout process, the greater part of which is broken away. Enough remains, however, to show that one of its faces had the same direction as the tibial (or inner) face of the femur itself.

The anterior end of the fractured surface, indicating the attachment of the base of this inner trochanter, is 18·5 inches distant from the proximal end, and the surface is about 8 inches long; so that its centre must have been situated on the proximal side of the middle of the length of the uninjured bone. A broad, but very shallow, depression marks the inner face of the femur above the base of this process.

The various sections presented by the ends of the fragments of the bone show that it contained a large and distinct medullary cavity, having a diameter of from two and a half to three inches.

The peculiar form of this femur, with the characters and position of its trochanters, leave no doubt as to the Dinosaurian affinities of the animal to which it belonged.

In size it must have corresponded with *Megalosaurus* and with moderately large Iguanodons. The largest femur of an *Iguanodon* with which I am acquainted is that marked No. 1 in the British Museum. It is 44·5 inches long, the middle of its shaft having a transverse diameter of 8 inches.

The Iguanodont femur in the British Museum figured by Professor Owen in his monograph upon that Reptile, published by the Palæontographical Society (pl. xv. fig. 1), is 33 inches long, the transverse diameter of the middle of the shaft being 5 inches.

The most perfect femur of *Megalosaurus Bucklandi* in the same collection is 32 inches long, while the middle of the shaft is not more than 4 inches in diameter. The largest Megalosaurian femur in the British Museum could hardly have exceeded 33 inches in length when entire.

The femur of *Scelidosaurus* is much smaller. Thus while the thigh-bone of the African Dinosaurian was probably nearly as long as that of *Megalosaurus*, it was absolutely, and *à fortiori* relatively, stouter.

On comparing the femora of *Megalosaurus* and *Iguanodon*, I find the following to be the chief differences between the two :—

In *Megalosaurus*—

a. The shaft is more slender and proportionally deeper from before backwards.

b. The inner trochanter lies almost wholly in the proximal half of the bone, so that its central, most projecting, part is much nearer the proximal than the distal end of the bone. In *Iguanodon* the most projecting part of the inner trochanter is a sudden outgrowth from its distal end, which lies altogether in the distal half of the bone.

c. One face of the inner trochanter continues the direction of the tibial (or inner) face of the femur. In *Iguanodon* one face of the inner trochanter looks towards the dorsal side of the femur, or is at right angles with the tibial face of the shaft, and there is a fossa above the trochanter on the tibial face of the femur.

d. The proximal end of the femur is curved, flattened, and twisted on its axis, so that the long axis of its transverse section makes an acute angle with that of the shaft of the bone. In *Iguanodon* the proximal end is flattened, but almost straight and not twisted on its axis, whence the long axis of its transverse section coincides, or nearly so, with that of the shaft of the bone.

e. The concavity of the upper face and convexity of the lower face of the proximal part of the femur is strongly marked. In *Iguanodon* both faces are almost flat.

f. The inner contour of the proximal part of the femur makes a slow and gradual curve. In *Iguanodon* it makes a sharp, almost rectangular, bend.

g. The great trochanter is comparatively short, not nearly reaching the proximal end of the bone. In *Iguanodon* it is long, slender, and its summit attains the level of the proximal end.

h. There is but a shallow and wide excavation on the front face of

the distal end of the femur. In *Iguanodon* there is a deep, sharply defined longitudinal furrow on this face, nearer the outer than the inner condyle.

i. The isthmus uniting the inner and outer condyles is wide from before backwards. In *Iguanodon* it is very narrow.

k. The outer condyle has a peculiar posterior ridge-like process, which appears to be absent in *Iguanodon*.

In the characters, *b*, *c*, *d*, *e*, *f*, *g*, the femur of the African reptile approaches that of *Megalosaurus* more nearly than that of *Iguanodon*; but it differs from that of *Megalosaurus* in the proportional size and form of its trochanters, and in its much heavier proportions.

An animal the thigh-bone of which approaches three feet in length, may be fitly said to have "good legs," whence I propose the generic name of *Euskelesaurus* for this new African reptile, and the specific title of *Brownii*, after its very intelligent and energetic discoverer, who in a letter dated the 18th of June, 1866, addressed to Sir R. I. Murchison, states that the thigh-bones now described (and the accompanying fossils numbered 1, 3, 4, 6, 9*a*, 9*b*, 20*a*, 20*b*, 21, and 49*a*, *b*, *c*, *d*, *e*) were obtained "in the Stormberg range of mountains in the division of Aliwal North, and about thirty miles from the town of Aliwal North. The fossils were found in a compact freestone rock, which also contains other organic remains. The height of the mountains from the base is about 3,500 feet, and about 9,500 feet from the sea; the strata containing the fossils about 1,200 feet from the base."

These additional fossils, and No. 47, of which I can find no mention in the list sent by Mr. Brown, have the same aspect, and appear to have been imbedded in the same matrix as the femora. Nos. 9*a*, 9*b*, and 49*a*, *b*, *c*, *d*, *e* are fragments of two very large flat bones, and 20*a*, 20*b* of a large metatarsal and metacarpal, which very probably belonged to *Euskelesaurus*. Nos. 4 and 21 are indeterminable.

No. 3 is a very interesting fossil, comprising nearly seven inches of the distal ends of a right tibia and fibula, with an astragalus in undisturbed position, though much mutilated. The width of the conjoined ends of the tibia and fibula is 7·8 inches, six inches being occupied by the tibia alone. The antero-posterior diameter of the tibia is 4·5 inches. The posterior surface presents a wide longitudinal groove; while the anterior appears somewhat trilobed, from the presence of two superficial longitudinal depressions. The astragalus is much damaged, but presents a general resemblance to that bone

in Crocodilia and in *Scelidosaurus*, its proximal end exhibiting a concave surface, and its distal a convex pulley.

No. 47 is the proximal end of a tibia, which answers very well to the foregoing in size. It is remarkable for the great size of its *cnemial* process, the inferior edge of which (so far as it is preserved) is rounded and concave, like the *procnemial* process in the Flamingo and the Albatros. These leg-bones would answer very well to the femur of *Euskelesaurus*.

No. 1 is the broken articular end of a long bone of considerable size, as the transverse diameter of its condyles when entire could have fallen but little short of eight inches. At seven inches from its extremity the shaft of the bone has a transverse diameter of 5·5 inches, an antero-posterior diameter of 6·6. The total length of the fragment is 10·75 inches.

The measurements of this fragment correspond pretty nearly with those of the distal end of the 33-inch *Iguanodon* femur. The two condyles are separated in front by a broad but well-marked groove the outer boundary of which is formed by a prominent ridge, separating the front face of the bone from the flattened outer face, which is disposed at right angles to the front face. The outer condyle, in which this ridge ends, is narrower than the inner, and projects further forward, but to a less distance backward. A very deep groove separates it from the inner condyle. The posterior surface of this condyle forms a stout projecting ridge, which runs up the length of what remains of the shaft of the bone, gradually diminishing in height. The tibial, or inner, surface of the inner condyle slopes obliquely inwards and backwards, as in the femora of *Iguanodon* and *Megalosaurus*.

I cannot identify this fragment with any part of a reptilian skeleton but the distal end of a femur; and if this interpretation be correct, it must belong to some other animal than *Euskelesaurus*, so much of the commencement of the distal expansion of the femur of the latter reptile remaining as to suffice to prove that it could not have had the peculiar form presented by the present specimen. Provisionally, and while awaiting further materials, I shall apply the title of *Orosaurus* to the fossil reptile indicated by the femur. Of course, the existence of a second great Dinosaurian in the Stormberg rocks renders it, for the present, impossible to assign the tibial fragments to the one genus or to the other.

The Stormberg mountains form part of a long range which stretches north-eastward for several hundred miles, and takes the name of the Drakenberg on the north-west frontier of Natal. In Mr.

ain's map and sections illustrative of the geology of South Africa, ublished in the seventh volume of the Transactions of this Society, ıis range of mountains is seen to be formed by the southern edge of considerable thickness of horizontal strata, piled conformably above ıe Karoo-beds, which have yielded the Dicynodonts and so many :her remarkable true reptiles and Labyrinthodonts.

According to Mr. Bain, "these Stormberg beds," as they might be ılled, contain reptilian and vegetable remains; but I know of no escription of any of these except that given by Professor Owen of ertain fossil remains, discovered by Messrs. Orpen in the Drakenberg, 50 miles from the Stormberg, which Professor Owen has called *Massospondylus*, *Pachyspondylus*, and *Leptospondylus*, and which he onsiders to "indicate three or more genera or species of large extinct ırnivorous reptiles, combining in their vertebræ and bones of the xtremities both Crocodilian and Lacertian characters, with an ıdication of a structure of the sacrum like that in the Dinosauria. heir precise place in the Reptilian class cannot be determined until ıe cranial and dental characters are known."[1]

I have carefully examined these fossil bones, which appertained animals of much smaller dimensions than *Euskelesaurus*, and, so r as they are comparable, differ from the latter.

The occurrence of Dinosaurian remains in the Stormberg rocks is, nfortunately, by no means decisive as to their geological relations. he Dinosaurian *Plateosaurus* has been discovered by Von Meyer in ıe Trias; and the affinities of the Thecodonts with the Dinosauria e so close that no one could be surprised at the occurrence of the tter reptiles in rocks of Permian age; while, on the other hand, ıey are continued through the Mesozoic formations to the Chalk.

In the letter from which a passage has already been cited, Mr. rown not only expresses the belief that he will be able to procure full suite of remains of *Euskelesaurus*; but this energetic investi- ator of South African geology promises shortly to forward another ighly interesting fossil, the account of which I subjoin in his own ords:—

"On the 24th of May last, being a holiday, I went into the ountry, as is my custom, and found, at a considerable distance from liwal, in an alluvial deposit forming the bed of an ancient valley, nbedded *in situ*, an animal which, from proofs in my possession, I elieve to be a representative animal, or at least the type of a genus hich inhabited a large extent of country.

[1] Descriptive Catalogue of the fossil organic remains of Reptilia and Pisces contained in e Museum of the Royal College of Surgeons of England (1854).

"When I send this animal I will transmit a series of fragments of teeth (belonging to this type) gathered from many parts of the district, and accompany them with a paper, with an outline sketch of the localities by the aid of a camera lucida.

"I have made already five visits to the spot. The following are the particulars :—

"*a.* The bones are completely mineralized, and very dense.
"*b.* There are about nine ribs as yet, with their vertebral ends in good preservation.
"*c.* Cranium (of which there are many pieces) very elongated. Saurian type?
"*d.* Lower jaws, very short and remarkably thick; no traces of teeth. Mammalian type?
"*e.* One large tooth in the upper jaw lying horizontally in the centre of the intermaxillary bone, and taking a curve after protruding from the muzzle. It is in such a peculiar position that I have seen nothing in nature or engravings resembling it.
"*f.* Twelve vertebræ, with their tubercles and processes complete.
"*g.* Several large bones, which I cannot define at present.
"*h.* One large bone belonging to the pelvis, possessing saurian characters."

Mr. Brown further remarks that the head must have been nearly as large as that of an ox, with lower jaws no longer than those of an average-sized dog.

It is useless to speculate when the means of arriving at certain knowledge are so near at hand; but the description is certainly more suggestive of a Dicynodont reptile than of anything else.

X

ON A NEW SPECIMEN OF TELERPETON ELGINENSE.

Quarterly Journal of the Geological Society of London, vol. xxiii., 1867, *pp.* 77–84. (*Read December* 19, 1866.)

I AM indebted to my friend the Rev. Dr. Gordon, of Birnie, by Elgin, for the opportunity of examining the very beautiful and important specimen of *Telerpeton Elginense*, of which I propose to give a description in the present paper. It is the property of Mr. James Grant, General Assembly Teacher, in Lossiemouth, Elgin, who has been good enough to entrust it to Dr. Gordon for transmission to me; and it was obtained from the well-known reptiliferous beds of Lossiemouth, along with some highly interesting fragments of *Stagonolepis* and *Hyperodapedon*.

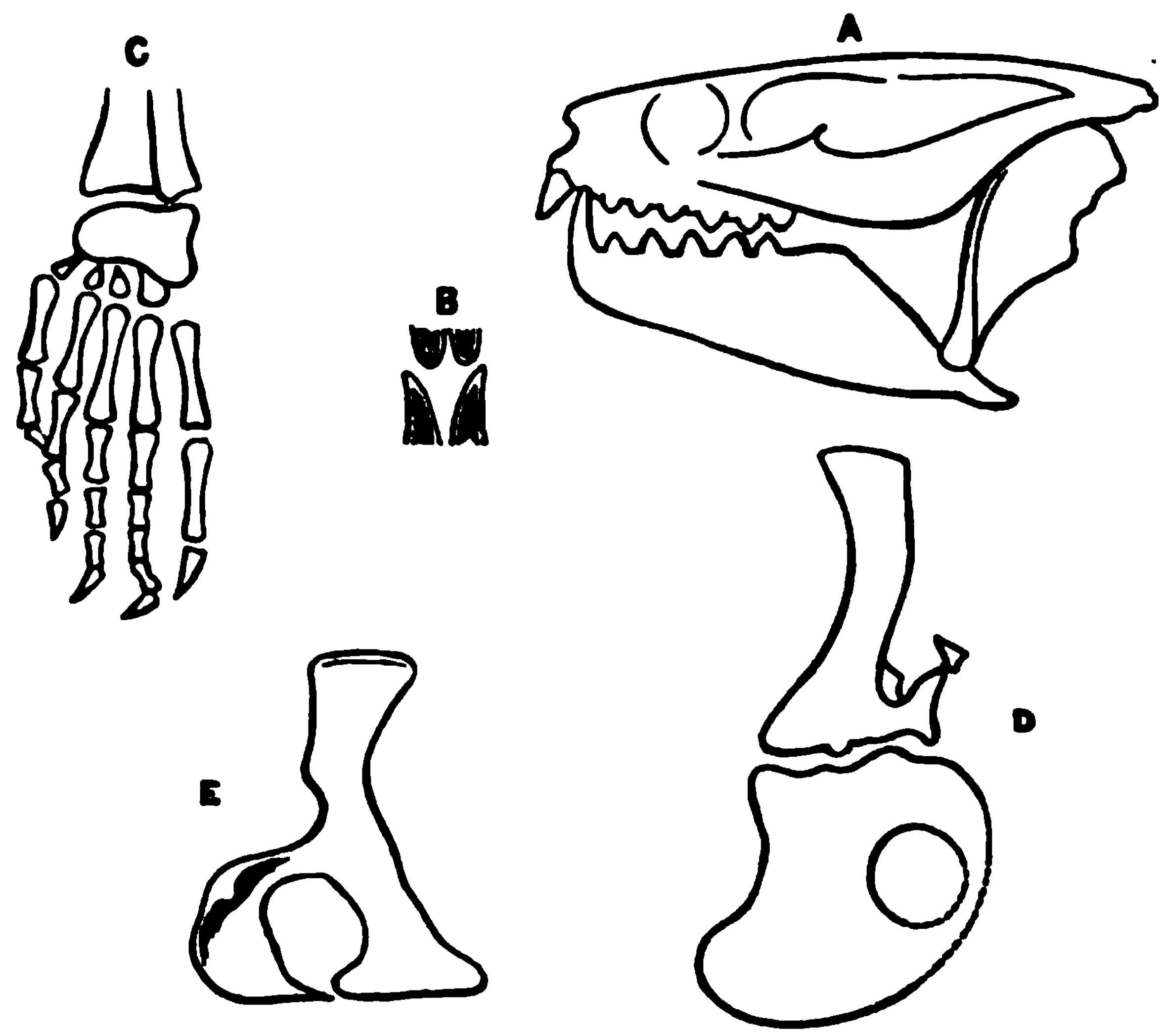
The fine-grained sandstone in which the fossil has been imbedded is broken irregularly into five pieces; and the several bones are represented by sharp and well-defined casts, the original osseous substance having disappeared, or being represented only by pulverulent bone-earth, or by oxide of iron. The body is curved towards the right side, and the head and neck are bent dorsad in a plane different from that of the trunk.

The length of the skull is 1·65 in., that of the vertebral column, from the atlas to the anterior margin of the sacrum, is 4·5 in. From the front margin of the sacrum to the end of the undisturbed part of the tail is 2 inches. To this total of 8·15 in. it is probable that 2 inches more, at least, must be added for the distal moiety of the tail, which would give the entire animal a length of not less than between ten and eleven inches.

The fore-limb had a length of not less than 2½ inches, while the hind-limb, when extended, must have measured fully 3 inches.

The skull is broad, its occipital margin measuring 1·5 in. The cranium retains this width for about half its length, and then rapidly narrows to the snout, with a contour which is at first convex, and then becomes concave, until it terminates in the roundly truncated snout, which exhibits the remains of two cylindrical incisor teeth, placed side by side and close together (fig. A.).

The posterior margin of the skull is nearly straight, but presents an obtuse angle directed backwards in the middle line. The postero-



FIGS. A—E. *Outline Sketches of parts of the Skeleton of* Telerpeton Elginense, *Mantell.* (Natural size.)

A. A side view of the skull.
B. The anterior teeth of the upper and lower jaws.
C The left hind-foot.
D. The right scapula and coracoid.
E. The left half of the pelvis.

lateral, or parietal, angles of the skull are produced directly outwards instead of backwards, into short and broad processes, which become connected with the strongly curved squamo-jugal arcades, the inner faces of which were concave and directed somewhat downwards.

The counterpart of the fragment which contains the greater part of the skull exhibits the impressions of part of the roof of the skull with the left orbit and left supratemporal fossa. It proves that the squamosal bone was large, thick, and slightly elongated posteriorly and externally, while its outer edge seems to have been undulated.

There is no evidence that any postfrontal bone separated the

temporal and the orbital fossæ, the two forming one oval space about 0·7 in. long and 0·4 in. wide. The roof of the skull can be traced forwards, narrowing gradually for a distance of 0·65 in., and then seems to have suddenly contracted to form the interorbital region. Here, however, it is completely hidden by the matrix.

In the prefrontal region it widens out again; and a curious, perfectly separate, sandstone cast of the interior of this part of the skull has been formed. This cast is shaped somewhat like an ace of spades, with a truncated apex and a trilobed base, and presents a few traces of bony matter upon its upper surface. The rest of its exterior is stained, for the most part, of a reddish colour, as if by oxide of iron.

The middle basal lobe presents a truncated, uncoloured surface, where it has broken off from the matrix which lies behind it. The anterior end is similarly fractured and unstained; and there are two oval, uncoloured elevated spaces on the under surface of the cast which answer to the posterior nares. All the rest of the cast has been enveloped in bone, which must have been furnished, at the sides, by the prefrontals and below by the vomers or the palatine bones. The impression of the upper surface of the vomers has left a strong median groove along the under surface of the cast. The surface of the matrix upon which this cast fits shows the remains of the oral faces of the facial bones, the bony matter itself appearing to be, for the most part, replaced by oxide of iron.

Each of the teeth, already mentioned, which are implanted in the præmaxillæ, is rather less than 0·1 in. wide, and rather more than 0·1 in. long. Their apices appear to have been rounded (fig. B).

The maxillæ are strong, and send up a process behind the external nostril. The roots of several teeth, placed in a single series from before backwards, occupy the alveolar surface of the thick anterior moiety of each. The palatine bones meet, and appear to be completely united in the middle line, nor does any posterior palatine space appear to be left between them and the transverse and maxillary bones. The very imperfectly preserved bony matter which remains is dotted over with rows of red spots of oxide of iron, the arrangement of which forcibly reminds me of that of the palatine teeth in *Hyperodapedon*, though I cannot make sure that these spots really represent teeth. Posteriorly the palatine bones meet the pterygoids, which diverge and pass backwards, to become connected with the quadrate bones in the ordinary way.

In the interspace between these the remains of the basi-sphenoid are visible.

The quadrate bone, 0·7 in. long, is strong; and its anterior aspect is convex forwards and from above downwards. It consists of an outer and an inner lamellæ, which pass into one another along the ridge-like anterior convexity of the bone, and enclose a deep cavity posteriorly. The distal end of the bone was provided with a transversely elongated convex condyle. The angle of the ramus of the mandible, which is 1·35 in. long, projects not more than 0·15 in. behind its articular surface (fig. A).

At the articular surface, the jaw is not more than 1·5 in. thick; but in front of this point it rapidly rises, and at 0·65 in. from the posterior extremity, forms a coronoid process, the summit of which is 0·4 in. distant from the lower edge of the ramus. It then declines in height, and at 0·75 in. from the angular end, begins to bear teeth. Of these teeth the three posterior occupy a space of 0·25 in., and each has a conical crown 0·1 inch high. Three teeth in the upper jaw, of similar size and form, interlock with them, the hindermost maxillary tooth being posterior to the hindermost mandibular tooth. The next two teeth, forwards, in the ramus of the mandible, are somewhat smaller than those just mentioned; but the most anterior tooth of all is a curved tusk, twice as long as any of the others, and having its concave side outwards, its convex side inwards and towards its fellow. These teeth bite behind the two long teeth lodged in the præmaxillæ (fig. B).

Three teeth in the upper jaw answer to the foregoing; and the anterior of these passes externally to the mandibular tusk when the mouth is closed. Thus there appear to be six teeth below, and seven teeth above, on each side of the upper and lower jaws; but it is possible that additional posterior teeth may not be visible.

I have carefully examined into the mode of implantation of those teeth, and I have been unable to satisfy myself that they are lodged in true alveoli. They appear to be anchylosed to the edges of the jaw-bones, as in many modern Lizards with a so-called "acrodont" dentition.

Each tooth contains a proportionally large pulp-cavity.

The vertebral column is broken in the middle of the dorsal region, and it is not practicable to ascertain the number of vertebræ with precision; but it may be safely assumed that the cervicodorsal series contains not fewer than twenty, and not more than twenty-two vertebræ. There are certainly not more than two sacral vertebræ. Eleven caudal vertebræ, belonging to the proximal half of the tail, lie in undisturbed relation to one another. There were probably as many more in the broken-up part of the tail.

The casts of these vertebræ show that they had completely ossified centra, very slightly concave at each end; large neural canals, and stout neural arches, running out into broad oblique processes or zygapophyses. The spines were very low narrow crests. The transverse processes must have been represented by mere tubercles.

Five long and slender vertebral ribs are visible on the right side of the anterior dorsal region, in connexion with a similar number of anterior dorsal vertebræ. The largest of these, though its distal end is not entire, measures 1·15 in. in length, but is nowhere more than 0·05 in. broad. These ribs are somewhat expanded at their proximal ends, but show no traces of a division into distinct capitula and tubercula.

On the left side the remains of several vertebral ribs, and a few slender grooves apparently produced by sternal ribs, are to be seen. The ribs of the four or five posterior dorsal vertebræ are exceedingly short; but there appear to be no proper lumbar vertebræ, in the sense of præsacral vertebræ with anchylosed or abortive ribs.

The cast of the only sacral vertebra which is visible shows it to have been possessed of a stout lateral process, 0·16 in. long, and 0·07 in. thick, which abutted against the ilium.

The ilium occupies such a position as to hide any other sacral vertebra which may have existed; but there could not have been more than one additional vertebra in this region of the spine. The eleven anterior caudal vertebræ occupy a space of 1·6 in., which gives rather more than 0·14 in. for the length of each vertebra. The anterior five or six possess slightly curved transverse processes, which taper to their extremities, and attain a length of 0·3 in.

The neural spines and subvertebral bones of the caudal vertebræ are not clearly exhibited.

Three vertebræ, following the tenth caudal, are represented by cylindroidal holes in the matrix, as much as 0·25 in. deep; and beside these lie imperfect impressions of yet two other elongated vertebral centres.

The left shoulder girdle is displayed on the upper surfaces of the first and second fragments, the line of breakage between which has in fact passed through this system of bones (fig. D).

The scapula was 0·8 in. long; and the cast proves that its proximal, or glenoidal, end was thick and prismatic, and slightly expanded anteriorly. Distally, or dorsally, it passes into a broad and flattened blade, not more than 0·2 in. wide, which is abruptly truncated at its vertebral end.

The coracoid must have been a very stout bone, nearly 0·9 in. in antero-posterior, and 0·5 in. in transverse measurement. Of its three margins the internal presents a convex, the anterior and the posterior a concave curvature. It appears to have possessed a considerable fenestra in the inner moiety of its anterior half.

An obscure impression, leading to a triangular hole, which is the transverse section of a cavity at least 0·2 inch deep, in the matrix, I believe to represent the cast of a clavicle. There is a corresponding hole and cavity in the counterpart fragment of the fossil. whence I conclude that the clavicle must have been about half an inch long.

The impression of the head of the humerus lies in its natural relation to the scapula and coronoid. It was 0·4 in. wide, and had a strongly marked deltoid ridge, or outer tuberosity, which projected downwards. In the counterpart the rest of the cast of the humerus is preserved, and proves that bone to have had a length of about 0·85 in. The middle of its shaft is not more than 0·2 in. wide, but its distal end expands to the width of the head.

The under surface of this fragment presented two holes in the position which the radius and ulna might well occupy; and on working away the matrix, I found that they led back into cavities which are the casts of these two bones. The narrower, answering to the ulna, is 0·6 in. long by 0·05 in. wide. The radial cavity is much broader, but its exact dimensions cannot be obtained.

The forearm is disposed nearly at right angles to the arm. At its distal end four minute rounded carpal ossicles, disposed in two rows, are discernible. Then come four metacarpal bones, the longest of which is the second from the radial side, and measures 0·3 in. This is succeeded by a short hourglass-shaped phalanx, 0·15 in. long. The metacarpal on the radial side of the preceding is 0·25 in. long. Those on the ulnar side seem to have been shorter and more slender. From some obscure indications of other phalanges I conclude that the fore-foot could not have been less than an inch long.

The cast of the left half of the pelvic girdle is well displayed (fig. E). The ilium was 0·5 in. long, 0·28 in. wide at its truncated end, slightly convex forwards, and concave backwards, and its long axis was apparently almost perpendicular to that of the vertebral column. The ischium and pubis were strong bones, meeting with their fellows at the symphysis; and the anterior margin of the pubis is produced downwards and forwards into a strong process. The shape of the obturator foramen is not distinctly shown. The casts of both of the femora are visible, and a part of the bony substance

of the right femur is preserved. The bone is 1·1 in. long, and has a sigmoid curvature, the greater part of its anterior contour being concave, that of its posterior contour convex. There appears to have been a prominent internal trochanter. The tibia and fibula are each 0·75 in. long; the former had a broad and expanded proximal end, and a comparatively narrow shaft, which widens again distally.

The cast of the left foot (fig. C) is very perfect, but not quite easy of interpretation. The fibula of the left leg is undisturbed: but the tibia lies obliquely across the fibula, with its femoral end on the outer, and its tarsal end on the inner side of the corresponding ends of the fibula. I conceive that while its tarsal end has remained in its proper position, the femoral end of the tibia has been dislocated; and, in this case, the cast will exhibit a dorsal view of the foot, the outer side of which will be fibular, while its inner side will be tibial. A single bone, 0·3 in. wide, and deeper on its fibular than on its tibial side, articulates with the tibia and fibula, and represents the calcaneum and astragalus. Between this bone and the three middle metatarsals, three small tarsal bones, forming a distal row, appear to have been interposed. The five metatarsal bones are perfectly represented by their casts. Each is subcylindrical, and wider at its articular ends than in the middle. The two outer are respectively 0·3 in. long, while the middle metatarsal is a very little longer. The two inner are each about 0·25 in. long, and the innermost is a somewhat stouter and thicker bone than the other. Of the digits the middle and the next outermost are equal and longest, each having a length of 0·5 in. Each exhibits, very distinctly, three hourglass-shaped phalanges and a terminal pointed and slightly curved ungual phalanx. A fifth phalanx appears to be interposed between the third and the ungual phalanges, in the outermost of these two digits. The digit on the inner side of the middle one is 0·35 in. long, and contains only three phalanges, two constricted in the middle and articular at each end, and the third ungual.

The innermost digit of all has a proximal phalanx 0·15 in. long, with both ends articular, and constricted in the middle. I think I can trace the impression of a second curved ungual phalanx lying across the next digit.

The outermost digit is very extraordinary; for it presents only two phalanges, one proximal, 0·27 in. in length, or as long as the proximal two phalanges of the longest digits, and a strong terminal ungual phalanx. This is so unlike the ordinary character of the fifth digit in Lacertilian Reptiles, that I was inclined at one time to think

that the foot had been turned round, and presented its plantar instead of its dorsal aspect to the eye. But its connection with the tibia and fibula, and the numerical relations of the phalanges of the other digits, are insuperable obstacles to the adoption of this view; and I can only suppose that what I have termed the "inner" digit is the hallux, and that the two longest digits are the third and the fourth.

From the description of the organization of *Telerpeton Elginense* which has now been given, it is obvious that this animal is one of the *Reptilia*, devoid of the slightest indication of affinity with the *Amphibia*. It is Saurian in all its characters; and if we inquire to what division of the Sauria *Telerpeton* belongs, there appears to me to be no doubt that it must be referred to the true *Lacertilia*, and among them to the suborder *Kionocrania* of Stannius, which contains all the modern Lizards—though I cannot make sure, from the present specimen, that it possessed a columella.

It will probably be objected that the concave articular faces of the centra of the vertebræ constitute an objection to this view, recent *Lacertilia* usually having concavo-convex vertebral centres. But, though Meckel pointed out the circumstance forty years ago, it has not always been duly remembered that biconcave vertebral centres, much more deeply excavated than those of *Telerpeton* appear to have been, are to be met with among the existing Geckos.[1]

I have referred to the difficulty of ascertaining the precise mode of implantation of the teeth in *Telerpeton*. If, as I believe, this Lizard is not Thecodont, but Acrodont, the only other important character by which it differs from existing *Lacertilia* is the structure of the fifth digit of the hind-foot, in which, however, it departs from all known Lacertilian reptiles, whether recent or fossil.

It is most interesting to observe that *Telerpeton* presents not a single character approximating it towards the type of the Permian *Protosauria*, nor to the Triassic *Rhynchosaurus* and other (probably Triassic) African and Asiatic allies of that genus,[2] nor to the Mesozoic *Dinosauria*; still less can it be considered a "generalized"

[1] See Meckel's 'System der vergleichenden Anatomie,' Theil ii. Abth. 1. p. 427 (1824):—"Andere dagegen, namentlich Gecko, verhältnissmässig doch nur eine geringe Anzahl, verhalten sich wie die Säugethiere oder noch richtiger den Fischen ähnlich; indem der Körper vorn und hinten eine beträchtliche, mit einer Knorpelbandmasse angefüllte, trichterförmige Höhle hat, wodurch er aus zwei Kegeln zusammengesetzt erscheint."

[2] The anterior tusk-like teeth are comparable to the anterior teeth of *Rhynchosaurus* and *Dicynodon*, only so far as these are comparable to the like teeth of many existing Lizards, e.g., *Uromastrix* and *Hatteria*.

form, or as, in any sense, a less perfectly organised creature than the Gecko, whose swift and noiseless run over walls and ceilings surprises the modern traveller in warmer climates than our own.[1] And whether the age of the deposit in which it occurs be Triassic or Devonian, *Telerpeton* is one of the most astonishing examples within my knowledge of a ***persistent type*** of animal organization.

[1] Dr. Mantell suggested that, should the Lacertian relations of *Telerpeton* be established, it probably differed but little in its physiognomy and economy from the small existing terrestrial Lizards.

XI

ON TWO WIDELY CONTRASTED FORMS OF THE HUMAN CRANIUM.

Journal of Anatomy and Physiology, vol. i., 1867, pp. 60–77.

THE two most thoroughly contrasted human skulls, taking them altogether, which have hitherto fallen under my notice, are those various aspects and sections of which, reduced to one-third of the size of nature, are represented in the accompanying woodcuts.

The one of these skulls, which I shall call *A*, belongs to the Museum of the Royal College of Surgeons of England, and is thus described in the "Osteological Catalogue."

"5484. The cranium of a native of Tartary.

"It is remarkable for its breadth and shortness, slightly convex superior surface, and broad, high, and vertical occipital surface. The forehead is broad but low. The nasal bones are large and prominent; the malars are not prominent. The anterior alveoli of the upper jaw slope forwards—*Hunterian.*"

For the opportunity of examining and making the requisite section of the other skull, *B*, I am indebted to J. B. Sedgwick, Esq., into whose possession it came, many years ago, as a "New Zealand" skull.

Among a good many New Zealand skulls which I have examined, however, none resemble this; while it presents so many Australian characters, that I am disposed to think it must have been obtained either in Australia, or in one of the Negrito islands. For it is a circumstance worthy of much attention, that the crania of the more or less woolly-haired Negrito inhabitants of Tasmania, New Caledonia, the Feejees, the New Hebrides, &c., present strongly Australian features, and are frequently altogether indistinguishable, by their external characters, from those of the leiotrichous Australians.

However, the precise origin of these skulls is not a matter of any moment in relation to my present purpose, which is simply to indicate

the nature, the extent, and the relations of the more important anatomical differences between the two skulls; and incidentally, to

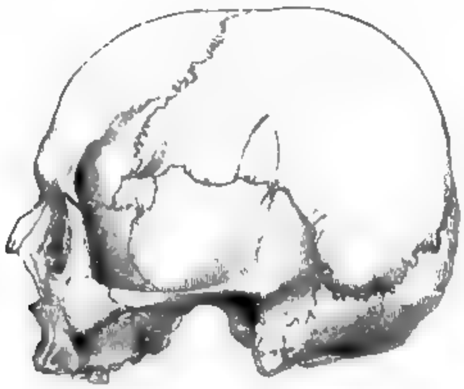


Fig. 1. The skull *A*. *Norma lateralis.*

illustrate the mode of comparing skulls which seems to me best calculated to render their real differences apparent.

The skull *A* is the broadest undistorted cranium which has come

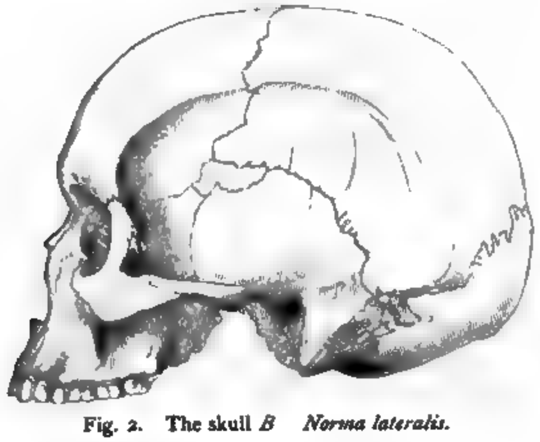


Fig. 2. The skull *B* *Norma lateralis.*

under my notice, its index being ·977. It is, therefore, eminently *brachistocephalic.*[1] When held out, at arm's length, so as to present

[1] Cephalic index	at or above ·80		= BRACHYCEPHALI, round skulls.	
....		. .. ·85	= *Brachistocephali.*	
.. ..	below ·85 and	. . . ·80	= *Eurycephali.*	
....	... ·80		= DOLICHOCEPHALI.	
.. ..	. . ·80	.. . ·77	= *Sub-brachycephali*	oval skulls.
....	... ·77	. . ·74	= *Orthocephali*	
....	.. ·74	... .. ·71	= *Mecocephali*	
....	.. ·71		= *Mecistocephali*, oblong skulls.	

See "Notes upon the Human Remains from Keiss," in Mr. Laing's *Prehistoric Remains of Caithness*, p. 85.

the *norma verticalis* to the eye (fig. 5), its bulging sides completely hide the zygomatic arches. It is, therefore, in Mr. Busk's nomenclature, *cryptozygous.*

The *squama occipitis* has a well marked convexity, separated in

Fig. 3. The skull *A*. *Norma facialis.*

Fig. 3*a*. The palate of the skull *A*.

the middle line by a depression (fig. 1) from the parietal region. A slighter depression occurs on the middle of the coronal suture; but, neither in this region, nor elsewhere, can I discover any indications of artificial distortion, unless a certain amount of asymmetry of the

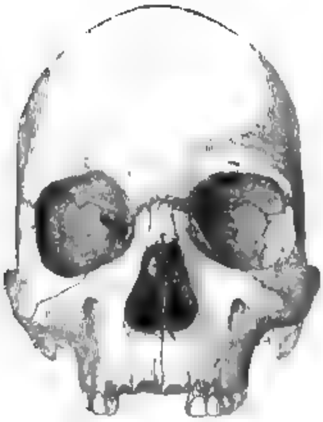


Fig. 4. The skull *B*. *Norma facialis.*

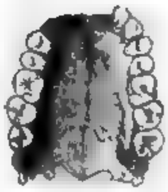


Fig. 4*a*. The palate of the skull *B*.

occiput (fig. 5), produced by the flattening of the right side (probably from nursing) can be regarded as such. The coronal suture is open, throughout its whole extent, on both the inner and the outer faces of the skull; as are the lambdoidal, occipito-mastoid, alisphenoidal,

squamosal, nasal, and fronto-nasal sutures. But the sagittal suture is so absolutely obliterated, that not a trace of it is discernible on either the outer, or the inner, surfaces of the skull (figs. 5 and 7).

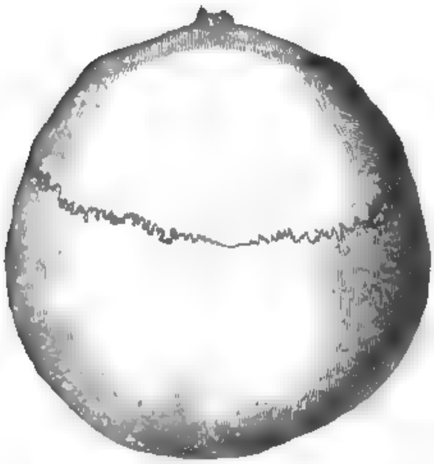


Fig. 5. The skull *A*. *Norma verticalis.*

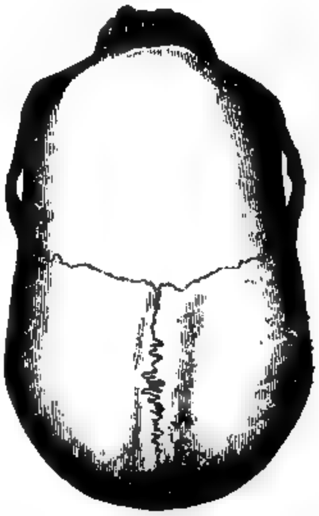


Fig. 6. The skull *B*. *Norma verticalis.*

The squamosal and the frontal are separated on both sides, partly by the parietal and partly by an intercalary bone, which is small on the right side, larger on the left, and lies between the parietal and the alisphenoid (fig. 1).

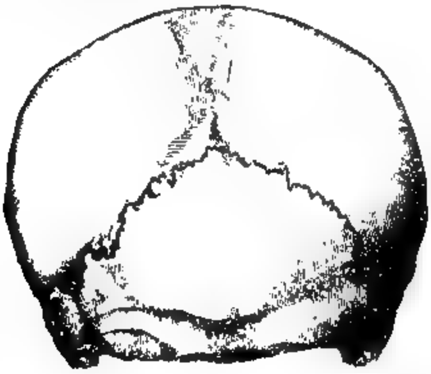


Fig. 7. The skull *A*. *Norma occipitalis.*

Fig. 8. The skull *B*. *Norma occipitalis.*

The auditory foramina are rounder than usual; the mastoid processes are well developed and prominent; the upper edge of the zygoma is nearly straight. The face is orthognathous, on the whole, though there is a certain amount of alveolar prognathism.

Turning to the base of the skull, the obliquity of the axes of the glenoid cavities is very remarkable. If these axes were prolonged inwards, they would cut one another as far back as the junction of the middle and anterior thirds of the occipital foramen. The axis of this foramen is directed downwards and forwards.

Traces of the maxillo-premaxillary suture are visible upon each side of the naso-palatine foramen. The palato-maxillary suture is unclosed, and convex forwards in the middle line (fig. 3*a*).

The frontal sinuses are extensive, and are separated by an imperforate septum which lies a little to the right of the middle line The body of the sphenoid and the roots of its lesser and greater alæ are occupied by the sphenoidal air-cells, the right cell extending back, beneath the sella turcica, to the posterior limit of the body of the basi-sphenoid.

The right second bicuspid and first true molar are the only teeth which remain, and their crowns are ground down to flat surfaces by wear. From this and other circumstances there can be no doubt that the possessor of this skull had attained middle age.

While *A* is the widest, *B* is the narrowest normal skull I have met with, its index being only ·629. It is, therefore, an extremely marked example of *mecistocephaly*. It is, further, *phænozygous*, the *norma verticalis* exhibiting a space between the zygomatic arches and the sides of the brain case (fig. 6).

The sagittal, coronal, lambdoidal, occipito-mastoid, alisphenoidal, squamosal, nasal, and fronto-nasal sutures, are open throughout their whole extent.

The frontal and the squamosal bones remain separate on both sides. On the left side, there is a considerable intercalary bone between the alisphenoid, parietal, frontal, and squamosal (fig. 2).

The auditory foramina are vertically elongated, perhaps more so than is usual : and they are, both absolutely and relatively, narrower than those of *A*. The mastoid processes are well developed and prominent. The upper edge of the zygoma is slightly convex upwards.

The face is obviously prognathous.

On the base of the cranium the axes of the glenoid cavities, if prolonged inwards, would cut one another about half an inch in front of the anterior edge of the occipital foramen, so that they are nearly transverse to the long axis of the skull. The axis of the occipital foramen is directed downwards and forwards. Faint indications of the maxillo-premaxillary sutures are discernible upon both

sides. The maxillo-palatine suture persists, and is arched forwards in the middle line (fig. 4*a*). The frontal sinuses are divided by a septum, which is inclined to the left side above. They are not quite so large as in *A*, but they are much larger than is usual in true Australian skulls.

The large sphenoidal air-cells are divided in the middle line by a septum. They do not extend back further than the middle of the pituitary fossa. The last molar is cut and in use; but the other teeth are only slightly worn. The skull may have belonged to a person of between twenty-five and thirty years of age.

In the *norma lateralis* (figs. 1 and 2), beside the points already mentioned, the great difference in the longitudinal contours of the two skulls is obvious. Further, the temporal ridge, sharply marked in *B*, is almost obsolete in *A*. The supra-auditory ridge, on the other hand, is more distinct in *A* than in *B*. The occipital spine is not very strong in either skull; and in both, the contour of the *squama occipitis* projects beyond it when the skull is horizontal. This projection is greater in *B*. In the *norma occipitalis* (figs. 7 and 8) there is a wonderful contrast between the spheroidal dome of *A* and the sharply ridged, wall-sided, pentagon of *B*; an opposition quite as marked in its way as that between the *normæ verticales* (figs. 5 and 6) of the two crania. The denticulations of the sutures are, for the most part, more simple in *B* than in *A*.

Each of the skulls *A* and *B* has been longitudinally and vertically bisected, and the outlines of each section having been accurately marked upon sheets of tracing paper, the one outline has been superimposed upon the other, in such a manner, that the *basicranial axes*[1] correspond in direction, while their anterior ends, situated at the point of junction of the presphenoid and ethmoid, coincide.

The resulting figure, reduced to one-half the size of nature, is given in fig. 9. In this figure *a*, *b* represents the basicranial axis; *bc*, *bc* lines drawn from the occipital end of the basicranial axis to the opposite boundary of the occipital foramen. The angle *a*, *b*, *c*, therefore, indicates the inclination of the plane of the occipital foramen to the basicranial axis, and will be small, or great, in proportion to the extent to which the occipital foramen looks forwards and downwards. It is analogous to, though not identical with, Daubenton's angle. *ad*, *ad* are lines drawn from the ethmoidal end of the basi-

[1] By *basicranial axis*, I mean a line drawn through the middle vertical plane of the *basi-occipital*, *basisphenoid* and *presphenoid*, from the hinder extremity of the former bone to the anterior extremity of the last, at the upper end of the ethmo-presphenoid suture.

cranial axis to the anterior edge of the premaxilla, where it bounds the nasal aperture. The angle *b, a, d,* may be termed the *premaxillary angle.*

ae, ae mark lines drawn from the ethmoidal end of the basicranial axis to the middle of the posterior margins of the palatine plates of the palatine bones. The angle *b, a, e,* may be termed the *post-palatine angle.*

The line *ag* is drawn from the anterior end of the basicranial axis, through the upper ends of the ethmo-frontal sutures, *f. f;*

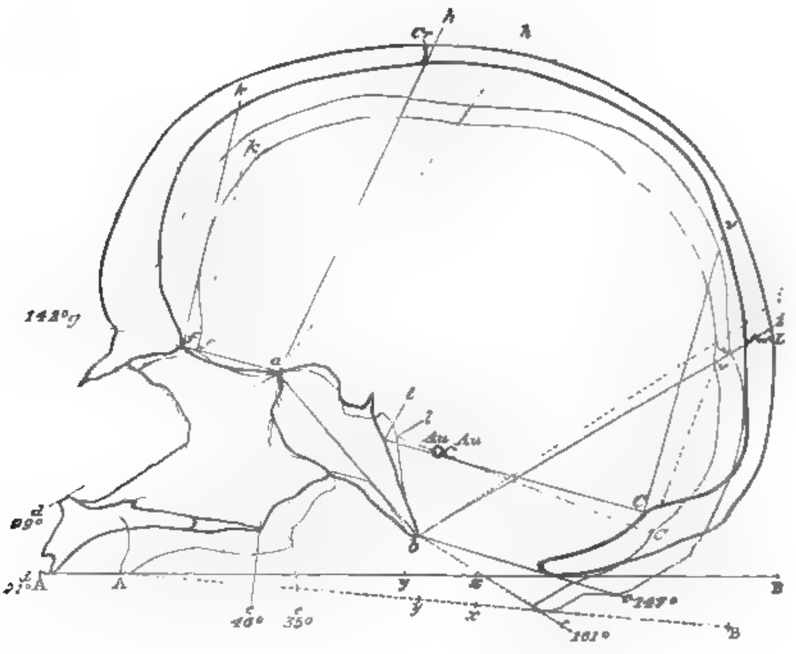


Fig. 9. Diagram exhibiting longitudinal and vertical sections of the skulls *A*, *B*, reduced to one-half the size of nature and superimposed. The thick contour lines and letters belong to *B*, the thin ones and the dotted lines to *A*.

af, *af* consequently indicate the lengths of the respective cribriform plates; while *ag* defines the general planes of those plates; which happen, in the present case, to coincide.

b, a, g, is the *basi-ethmoidal angle,* which diminishes in proportion as the line *ag* rotates downwards upon *a*; or, in other words, in proportion to the departure of the human skull from the condition of that of the lower *Mammalia.*

fk, fk are perpendiculars to the line *ag* erected upon the point *f*.

The distance between these lines and the inner contour of the frontal bones is a measure of the *anterior cerebral overlap* ; or, of the extent to which the frontal lobes of the brain project beyond the extremities of the olfactory nerves. *ah*, *ah* ; *ai*, *ai*, are lines drawn from the anterior end of the basicranial axis to the middle of the coronal and lambdoidal sutures *Cr*, *L*.

lC, *lC* are lines drawn from *l*, *l*, the points at which the inner end of the posterior superior margin of the petrosal cuts the basicranial axis, to the *torcular Herophili*. Each may be taken to represent the *tentorial plane*, though, of course, the centre of the tentorium would rise considerably above it. *Cv* is a perpendicular erected upon the hinder end of this line and marking the projection of the cerebral hemispheres beyond the cerebellum, or the *posterior cerebral overlap*, *AB* is a line representing the extreme length of the entire cranium ; *y*, its centre ; *x*, the point cut by a perpendicular from the centre of the occipital foramen. *Au* the internal auditory foramen, *L* the lambdoidal, *Cr* the coronal suture.

The various measurements of the two skulls, to which I shall have to advert, may be conveniently classified under three heads: 1stly, those which are identical; 2ndly, those which differ by not more than five per cent.; 3rdly, those which differ more than five per cent.

They are given in $\frac{1}{100}$ths of an inch, not from any desire to affect an accuracy to which cranial measurements can lay no claim, but for the sake of more ready comparison. It must be understood that very few cranial measurements will come out exactly alike twice over ; so that the numbers given must in most cases be regarded simply as a mean ; the variations from which will not affect the general result.

I. *Identical measurements (in $\frac{1}{100}$ths of an inch).*

		A.	*B.*
1.	The basicranial axis	235	235
2.	The vertical height of the face from the fronto-nasal suture to the alveolar margin	260	260
3.	The vertical height of the orbital aperture	135	135
4.	Anterior interlachrymal diameter, from the point of junction of the frontal, lachrymal and maxillary, on the one side, to that on the other	75	75
5.	From the margin of the orbit to the alveolar margin between m^1 and m^2	175	175
6.	The greatest breadth of the palate taken between the inner edges of the alveoli	140	140
7.	The greatest length of the palatine plate of the palate-bone	75	75

II. *Measurements which do not differ more than* 5%.

Differences in favour of *B* are marked with a *.

		A.	*B.*	Diff.
8.	The longitudinal arc of the frontal...	512	537	*25
9.	The longitudinal arc of the occipital	430	426	4
10.	The greatest transverse diameter of the occipital bone from one occipito-mastoid suture to the other	443	422	21
11.	The length of the occipital foramen	145	140	5
12.	The distance of the suborbital foramina	230	220	10
13.	The length of the zygoma from the anterior edge of the auditory foramen to the anterior end of the maxillo-jugal suture ...	310	323	*13

III. *Measurements which differ more than* 5%.

		A.	*B.*	Diff.
14.	Extreme length	670	755	*85
15.	Extreme breadth	655[1]	475[2]	180
16.	Height	480	530	*50
17.	Longitudinal arc of the parietals	450	550	*100
18.	Transverse arc from one auditory foramen to the other	1350	1175	175
19.	Width of the frontals immediately behind the external orbital process (least frontal measurement)	405	340	65
20.	Width of the frontals on the temporal ridge just above the external orbital process	417	375	42
21.	The greatest frontal width, where the temporal ridge cuts the coronal suture	555	395	160
22.	Length of the cribriform plate	95	107	*12
23.	Posterior interlachrymal diameter, between the junctions of the ethmoid, lachrymal and frontal	105	90	15
24.	Between the posterior ends of the ethmo-maxillary sutures ...	170	155	15
25.	Between the outer edges of the optic foramina in the interior of the skull	126	85	41
26.	Between the outer edges of the optic foramina in the orbits ...	155	115	40
27.	Between the outer sides and posterior edges of the bases of the external pterygoid processes	205	176	29
28.	Between the points of the alispheno-squamosal sutures, which are cut by the transverse ridge on the alisphenoid	360	320	40
29.	Between the outer edges of the foramina ovalia	240	193	47
30.	Between the posterior ends of the alispheno-squamosal sutures and outer sides of spinous processes	305	245	60
31.	Between the outer edges of the glenoidal fossæ	533	455	78
32.	Between the most distant points of the outer surfaces of the mastoid processes	536	452	84
33.	Transverse arc of the occipital, from the junction of the lambdoidal suture and its additamentum on one side, horizontally over the occiput to the other side	500	636	*136
34.	Between the centres of the styloid foramina	360	290	70
35.	Least breadth of the basicranial axis (between the apices of the *partes petrosæ*)	100	75	25

[1] Between the upper edges of the squamosals, over the auditory foramina.
[2] Between the parietal tuberosities.

		A.	B.	Diff.
36.	Between the inner edges of the precondyloid foramina	150	125	25
37.	Between the most distant points of the outer edges of the occipital condyles	215	185	30
38.	Transverse diameter of the occipital foramen	125	105	20
39.	Between the internal auditory meatuses	245	155	90
40.	Length of the posterior superior edges of the ossa petrosa ...	270	245	25
41.	Extreme transverse distance of the outer surfaces of the zygomata	555	485	70
42.	From the lower end of the basicranial axis to the anterior alveolar margin of the pre-maxilla	332	420	*88
43.	From the lower end of the basicranial axis to the posterior end of the spine of the palate	137	165	*28
44.	Extreme distance of the outer surfaces of the maxillæ	220	242	*22
45.	Width of the external nasal aperture	92	105	*13
46.	Greatest perpendicular height of the nasal passage, from the cribriform plate to the upper surface of the palate	177	160	17
47.	Extreme distance of the outer walls of the posterior nares ...	115	98	17
48.	Height of the arch of the posterior nares	100	92	8
49.	From the posterior end of the spine of the palate to the anterior margin of the pre-maxillæ	195	253	*58
50.	Length of a line drawn from the anterior edge of the premaxilla along the posterior edge of the occipital foramen, and cut by a perpendicular tangent to the occiput, *A*, *B*, fig. 9 ...	660	810	*150
51.	Length of so much of this line as lies in front of a point cut by a perpendicular to the centre of the occipital foramen (*A*, *x*) ...	390	480	*90
52.	Length of the line behind this point (*x*, *B*)	270	330	*60
53.	Projection of the inner contour of the frontal beyond the level of a perpendicular to the anterior end of the cribriform plate (= anterior cerebral overlap)	20	55	*35
54.	Projection of the inner contour of the occipital beyond the *torcular Herophili* (= posterior cerebral overlap)	30	85	*55
55.	The capacity of the cranium and volume of the brain, as determined by the volume of a cast of the interior of the skull, in cubic inches	95	80	15
56.	Extreme length of the cast	625	695	*70
57.	Extreme breadth	615	455	160
58.	Breadth : length = 100	98	65	33

1. The first point to be noted in comparing the skulls *A* and *B*, the most important measurements of which have now been given, is the equality of length of their *basicranial axes*, which proves that brachycephaly and dolichocephaly are not necessarily connected with the shortening or the lengthening of the base of the skull; but that their most extreme forms may arise exclusively from modification of the side walls and roof of the cranium. In the present case, the difference in the absolute lengths of the two skulls amounts to about 11% of the length of the longer (*B*). It is due, in part, to the remarkable shortness of the parietal region in *A*, the longitudinal arc of the parietals being about 18% (No. 17), and its chord 20%, longer in *B*

than in *A*. In part, the superior length of *B* arises from the forward extension of the frontal region, which will be more particularly discussed below. The elongation of the occipital region does not seem to be greater than that which would necessarily accompany the lengthening of the parietals.

The difference in breadth between *A* and *B* (No. 15) amounts to 27% of the broader. It is greater absolutely and relatively than the sum of the excess of height and length of *B* over *A*.

2. Virchow's "sattel-winkel" is substantially the same in the two skulls, though the one is vastly more prognathous than the other. Hence it follows that there is no necessary connection between the "sattel-winkel" and prognathism or orthognathism.

3. It will be observed, that only one pair of the transverse measurements, which differ less than 5%, appertain to the brain-case. These are No. 10, the greatest transverse diameters of the occipital bone. In all the other transverse measurements of the brain-case (with the exception of No. 33, the transverse arc of the occipital, which is in reality as much a longitudinal as a transverse dimension) *A* exceeds *B*. Hence it appears that, in such a thorough example of brachycephaly as this, the excess of transverse growth is general, and affects all parts of the brain-case. But the excess is not equal in all regions of the skull.

Thus in No.	35	the excess of *A* is about	25%
....	39	....	36%
....	36	....	16%
....	34	....	19%
....	32	....	15%
....	31	....	14%
....	30	....	20%
....	29	....	19%
....	28	....	11%
....	27	....	14%
....	25	....	33%
....	21	....	29%
....	19	....	16%
....	15	....	27%

The measurements which exhibit the smallest difference (No. 28), represent roughly the distances of the apices of the temporal lobes of the brain. The greatest differences are shown by the base of the brain in the region of the pons and anterior part of the medulla (No. 39); by the exits of the optic nerves (No. 25); by the region corresponding with the outer sides of the frontal lobes (No. 21); by the region corresponding with the outer sides of the parietal lobes,

or the posterior and upper parts of the temporal lobes (No. 15); and by the width of the basicranial axis itself.

It will be very interesting to ascertain, from similar measurements of other skulls, to what extent the rule observed in these, that in skulls with equal basicranial axes[1] *dolichocephali* are absolutely narrower than *brachycephali* in their transverse diameters, holds good. Even in the present cases there is the remarkable exception with regard to the transverse diameters of the occipital (No. 10), which has already been noted; and it is, of course, quite conceivable that the diameters of the base of the cranium should vary irrespectively of those of its side walls. But a skull which should derive its excess in breadth from a development of its side walls alone, exhibiting what might be called *lateral brachycephaly*, would obviously have a different significance from one which, like *A*, is *basally*, as well as *laterally*, *brachycephalic*. And similar considerations apply to *dolichocephaly*.

4. By "vertical height" in the foregoing table of measurements, I mean the distance from the posterior and inferior end of the basicranial axis to the point of intersection of the coronal and sagittal sutures. These are convenient fixed points, and although a line joining them is by no means constantly perpendicular to a longitudinal axis of the skull, or inclined at any invariable angle to the basicranial axis, yet, practically, it hardly ever differs more than a tenth of an inch from a more strictly vertical measurement.

The vertical height of *B* exceeds that of *A* by about 10%; but while *A* is within 0·1 inch as low as any skull I have met with, *B* is not more than half way towards the maximum of height which I have observed, and which is about an inch greater than that of *B*.

The following table of a few measurements of sections of crania seems to show that the height of skulls as thus estimated, varies without much reference to their other measurements.

	Length of the basicranial axis.	Height.	Cephalic index.
1. Scutari (Turk? 5563 A)	245	575*	·88
2. Japanese	290	570	·75
3. Redondo (Negro)........................	275	570*	.72

*** The * indicates that the height of the parietal region exceeds that given by about 0·1 inch. The remarkable length of the basicranial axis in Nos. 2, 3, and 7 must be taken into account. The numbers refer to the Catalogue of the Museum of the Royal College of Surgeons.

[1] In comparing skulls the lengths of the respective basicranial axes must be carefully taken into account. Had the basicranial axes of *A* and *B* been unequal I should have given all the measurements of each skull in terms of its own basicranial axis; but as they are equal, I have not thought it worth while to take the trouble of making the requisite calculations.

		Length of the basicranial axis.	Height.	Cephalic index
4.	Australian (5317)	250	565	·68
5.	Tasmanian (5324)	225	550	·76
6.	English (5733)	250	550	·74
7.	Japanese	272	550*	·75
8.	Australian (5307)	250	545	·69
9.	The skull *B*	235	530	·629
10.	Australian	230	530	
11.	Chinese (5474)	235	535*	·75
12.	Malay (5463 A)	240	510*	·88
13.	Japanese	240	490*	·76
14.	Australian (5331)	?	490	·71
15.	Mondombe (Negro)	230	480	·74
16.	The skull *A*	235	480	·977

* For explanation, see previous page.

5. Certain important differences between the skulls *A* and *B*, which would not be brought out by the ordinary methods of measurement and comparison, become very obvious in the sectional diagram (fig. 9). Thus, the spaces behind the lines *Cv*, *Cv*, and in front of *f*, *k*, *f*, *k* are very much greater in *B* than in *A*, showing that the cerebral hemispheres overlapped the cerebellum behind and the cerebrum in front, for a much greater distance in *B* than in *A*. The distance between the anterior contour of the cranial cavity and the anterior end of the basicranial axis in *B* is further increased by the greater length of the cribriform plate *a*, *f*. Hence, if we call the space comprised between the lines *a*, *h*, *a*, *f*, and the anterior inner contour of the frontal bone, the *frontal area* of the longitudinal section, this *frontal area* is absolutely greater and projects further forwards in *B* than in *A*. The difference between the two skulls thus produced is further exaggerated by a sort of rotation of the whole cranial chamber upon its axis, forwards in *B* and backwards in *A*. Thus the whole forehead, with the coronal suture, is thrown backwards in *A*, and the occipital plane, partaking in the same movement, forms a more open angle with the basicranial axis than that of *B*. The tentorial plane has shifted in the same sense to a less degree. The line *b*, *i*, in *A*, on the other hand, is a little in advance of the corresponding line in *B*, probably in consequence of the remarkable brevity of the parietal bones.

The skulls *A* and *B* present as complete a contrast as any I have seen in regard to this remarkable rotation of the skull upon its basal axis. But it must not be supposed that the backward rotation is connected with brachycephaly, or the forward rotation with dolichocephaly. I have sections of two dolichocephalic Australian skulls

which differ as widely as *A* and *B* in the anterior region of the skull. I have other sections of brachycephalic skulls, in which the frontal contour lies far in advance of that of *A*, though I have not yet met with a brachycephalic skull having so great a forward rotation of the frontal region as *B*.

As a rule, the coronal suture is situated forward with forward rotation of the skull; backward, in the contrary case. But neither the lambdoidal suture, nor the posterior edge of the occipital foramen, necessarily follows it. In a negro skull, with nearly the same extent of backward rotation of the frontal region as in *A*, the line *b c* makes an angle of only 135° with *a b*, or 26° less than in the case of *A*.

The influence of the backward and forward rotation of the frontal region of the skull upon orthognathism and prognathism, as they are ordinarily estimated, is obvious. The so-called *facial angle*, in fact, does not simply express the development of the jaws in relation to the face, but is the product of two factors, a facial and a cranial, which vary independently. The face remaining the same, prognathism may be indefinitely increased, or diminished, by the rotation of the frontal region of the skull, backwards or forwards, upon the anterior end of the basicranial axis.

If *B* had the frontal contour of *A*, it would be an extremely marked example of orthognathism, or rather of what Welcker has called "opisthognathism"; while, if *A* had the frontal contour of *B*, it would appear to be marvellously prognathous. And yet in neither case would there be any change in the jaws, but only so much modification in the position of the cranial cavity relatively to its axis, as can be shown to occur among skulls belonging to the same stock.

6. The real differences in the disposition of the facial bones relatively to the basicranial axis, or, in other words, the amount of true *prognathism* or *orthognathism*, cannot, in fact, be safely estimated by any of the accepted "facial angles." The sectional diagram shows that *B* is truly much more prognathous than *A*, the differences between the two being of three kinds.

(*a*) The vertical height of the nasal cavity is somewhat less in *B* than in *A*.

(*b*) The length of the palate is greater in *B* than in *A*.

(*c*) Lines drawn from the anterior end of the basicranial axis to the posterior and anterior margins of the floor of the nasal cavities (*a e*, *a d*) form more open angles (*premaxillary* and *postpalatine angles*) with *a*, *b* in *B*, than they do in *A*. In other words, the centre of the palate has, so to speak, moved forwards in *B*.

Increase in the absolute length of the palate and shifting forward

of the centre of the palate, are competent, singly or together, to produce true prognathism, other conditions remaining unaltered. But shortening of the vertical height of the nasal chamber alone is consistent with the preservation of complete orthognathism. As a general rule, however, the three conditions are concomitant, as in *A* and *B*; the more prognathous skull having a lower nasal chamber as well as a longer palate, and a shifting forward of the centre of the palate.

Practically, I should say that the angle *b, a, d* fairly represents the degree of true prognathism; and I think it will be found convenient to consider skulls in which that angle is less than 95° as orthognathous, and those in which it is greater as prognathous. The most prognathous skull I have met with had the angle *b, a, d*=110°; in the most orthognathous it was only 83°. I doubt if the angle ranges much beyond 30°.

7. The vertical measurements of the face (Nos. 2, 3, 5, 46, 48) either agree, or differ but little, the excess being in favour of *A* (Nos. 46, 48). Among the longitudinal measurements, those of the palatine plates of the palatine bones agree (No. 7), showing that the difference in the lengths of the palates is wholly due to the premaxillæ and maxillæ. Again, the lengths of the zygomata differ only to an inconsiderable extent, whence it follows that the excess of longitudinal growth is in the alveolar, rather than in the orbital parts of the maxillæ. No. 42 shows that the margin of the premaxilla is ·88 inch more distant from the lower end of the basicranial axis in *B* than in *A*; but No. 43 proves that 0·28 of this amount is due, not to the excessive growth of the maxilla and premaxilla, but to the shifting forward of the palate as a whole.

8. Taking the length of a line *A, B*, drawn from the anterior alveolar margin of the premaxilla along the posterior edge of the occipital foramen and cut by a perpendicular tangent to the posterior face of the occiput, to represent the basal length of the whole skull (No. 50), it is much longer (1·5 inch) in *B* than in *A*. Nevertheless, the extra length of *B* is so distributed that the centre of the occipital foramen (*x*) is in exactly the same place in the two skulls, viz. at three-fifths of the length of the line *A, B* from its anterior end.

9. Although *A* is cryptozygous and *B* phænozygous, the interzygomatic width of the face is greater in *A* than in *B* by about 12% (No. 41). But the maxillary diameter (No. 44), on the contrary, is about 9% greater in *B* than in *A*. This arises, however, chiefly from

the less development of the alveoli themselves in *A*, seeing that the breadth of the palate inside the alveoli (No. 7) is the same in the two. The distances of the suborbital foramina (No. 12) are nearly the same in the two skulls, and those of the upper ends of the ascending processes of the maxillary are identical. Hence the greater width of the face in *A* is not due to any excess in the size of the bodies of the maxillary or premaxillary bones, but to the increased transverse diameter of the frontals (Nos. 19, 20), which push the jugal bones outwards. This is accompanied by a certain increase in the diameter of the ethmoid (Nos. 23, 24), of the distance between the optic foramina (No. 26), and of the width of the posterior nares (No. 47).

10. In describing the general characters of the two skulls I have mentioned the interesting fact that the chief sutures of *B*, the very long skull, are completely open; but that the sagittal suture of *A*, the very short and broad skull, is thoroughly obliterated, while the other great sutures named are still open.

It is therefore clear that extreme brachycephaly is consistent with comparatively early synostosis of the parietal bones; or, in other words, that synostosis of those bones may take place comparatively early and yet have no discernible effect upon the form of the skull.

This is, in fact, perfectly obvious from the nature of the case. For the final proportions of the brain-case of the human skull are attained in early manhood, while the sagittal suture ordinarily remains open till late in life; and it can make no manner of difference to the shape of the brain-case whether the sagittal suture becomes obliterated at thirty, or at fifty, years of age, if the brain-case assumes its final proportions at twenty-five.

When the skull of a man of middle age, of unknown stock, with obliterated sagittal suture, is placed before an anatomist, he possesses absolutely no evidence respecting the period at which the obliteration took place; and, consequently, he has no means of judging whether the synostosis has, or has not, had any share in producing the form of the skull. If the cephalic index of the skull be greater than ·70, he has not the least right to suppose that the synostosis has had any effect, inasmuch as there is abundant evidence to prove that crania with lower cephalic indices exhibit no such synostosis.

The Neanderthal skull belongs to a man of middle age, is of unknown stock, and has a cephalic index of ·72. There is consequently not a shadow of justification for the assumption that any

obliteration of the sagittal suture which it presents has had more effect in narrowing its proportions, than the obliteration of the sagittal suture in *A* has had upon the configuration of that exceedingly broad skull.[1]

[1] With the permission of the Museum Committee of the Royal College of Surgeons, and of Mr. Sedgwick, casts of the skulls *A* and *B* and of their cavities, representing the corresponding brains, have been made and are to be obtained of Mr. Gregory, Russell Street, Covent Garden.

XII

ON ACANTHOPHOLIS HORRIDUS, A NEW REPTILE FROM THE CHALK-MARL.

The Geological Magazine, vol. iv., 1867, *pp.* 65–67.

PLATE V. [PLATE 22].

SOME time since, my colleague, Dr. Percy, purchased from Mr. Griffiths, of Folkestone, and sent to me, certain fossils from the Chalk-marl near that town, which appeared to possess unusual characters. On examining them I found that they were large scutes and spines entering into the dermal armour of what, I did not doubt, was a large reptile allied to *Scelidosaurus*, *Hylæosaurus*, and *Polacanthus.* I therefore requested Mr. Griffiths to procure for me every fragment of the skeleton which he could procure from the somewhat inconvenient locality (between tide-marks) in which the remains had been found, and I eventually succeeded in obtaining three teeth, with a number of fragments of vertebræ, part of the skull and limb-bones, besides a large additional quantity of scutes. I am still not without hope of recovering other parts of the skeleton; but as the remains in my hands are sufficient to enable me to form a tolerably clear notion of the animal's structure, a brief notice of its main features will probably interest the readers of the GEOLOGICAL MAGAZINE.

The dermal bony plates or scutes (Plate V., Figs. 1—3 [Plate 22]) are of very various forms and sizes, from oval disks slightly raised in the middle, and hardly more than an inch in diameter, up to such great spines as that represented in Plate V., Fig. 1 [Plate 22], which could have fallen little short of nine inches in length and five inches in the antero-posterior measurement of its base. The outer surface of all these scutes is irregularly pitted and, in the case of the long spines, is occasionally marked by branching grooves which doubtless lodged vessels.

Each scute is excavated on its attached face in proportion to the elevation of its outer surface, so that a transverse section of one of the depressed scutes is more or less roof-like, while that of one of the long spines shows it to possess a great internal cavity like the medullary cavity of an ordinary bone.

Some of the scutes, though comparatively few, are almost flat, with an obtuse median ridge, which is highest about the middle of the scute (Plate V., Fig. 3 [Plate 22]). But when the ridge is more prominent, as in Plate V., Fig. 2 [Plate 22], its summit is usually placed very much nearer one edge than the other, so that one side of the triangular lateral aspect is much shorter and more perpendicular than the other. The short side, however, is not absolutely perpendicular in any scute among those which have reached me, and the summit consequently always lies within the circumference and never overhangs it.

The spine-like dermal plates are altogether unsymmetrical. If, as I suppose, the convex edge of that represented in Plate V., Fig. 1 [Plate 22] was anterior, then the posterior edge is concave, and the left side convex, with a slight longitudinal excavation in its anterior half; while the right side is much more deeply hollowed in the same direction. Furthermore, the anterior, convex, edge is not straight, but is slightly concave towards the left, and convex towards the right side; while the posterior, concave, edge is concave towards the right, and convex towards the left side. The ridge which forms the posterior edge is suddenly interrupted near the base of the spine by a deep notch, (Fig. 1, *a*) which probably received the anterior edge of the next succeeding spine. The transverse diameter of the base of this spine could not have been less than four inches when it was entire.

I estimate that the more or less complete remains of nearly a hundred scutes of the different forms now mentioned, must have passed through my hands, and, as they all came from one small area, they probably belonged to one animal.

Such vertebræ as have been obtained, are in a very fragmentary state. The body of a dorsal vertebra is about 1·5 in. high, but has a less width; its length cannot have exceeded two inches. Its articular ends are very slightly concave, and it is somewhat narrower in the middle than at the ends. The neural canal is spacious being not less than one inch high. The neural spine appears to have been low and inclined somewhat backwards. Another detached body of a dorsal vertebra is 2·1 in. long, 0·2 in. high, 1·85 in. wide at its articular ends, and 1·5 wide in its centre. The sacrum of this reptile would be very interesting, but no fragment of that part of its skeleton has as yet made its appearance. Of the skull I possess

only a very much mutilated fragment, showing the basioccipital and basisphenoid. The occipital condyle measures 1·4 transversely, or has about the same diameter as that of the skull of a *Crocodilus biporcatus*, which measures 16 inches in length, from snout to occiput. But it is more elongated transversely and excavated above than in the Crocodile, and the exoccipitals enter more largely into its composition. The Crocodilian disposition of the Eustachian tubes is absent, and the carotids run up the side of the basisphenoid in Lacertilian fashion. The *sslla turcica* has a well developed posterior plate.

Only three teeth have been found in connexion with these remains, but one of them is in a very perfect state, and was readily detached from the matrix, so as to be easily viewed from all sides (Plate V., Fig. 4, *a*, *b*, *c* [Plate 22]). The crown is broken off from the fang, which another specimen shows to be about as long as the crown and subcylindrical. The crown is nearly 0·4 long, the greater diameter of its base is 0·27, and the less about 0·2 ; it is shaped like a lance-head, with an acute point and sharp edges ; these edges are notched in such a manner that the crown exhibits eight serrations on each side of its apex. The enlargement of the crown into its swollen base is somewhat sudden, and takes place higher up on the one face of the tooth than in the other, so that when the tooth is viewed from one edge the one face appears concave and the other convex (Plate V., Fig. 4, *b* [Plate 22]).

The most curious feature about this tooth, however, is its colour. The ground hue of the crown is pale brown, but vertical lines of dark chocolate colour run vertically and parallel to one another from the serrated edge to the swollen base, on which they die out. The middle of each intermediate pale brown band exhibits a very delicate dark line.

One of these pale brown bands occupies the middle of each face of the tooth and its apex. On each side of this are six or seven dark bands and as many interspaces. The dark bands correspond pretty nearly, but not exactly, with the summits of the serrations.

The shape of these teeth is quite different from that of the teeth of *Scelidosaurus*, which they approach most nearly.

The most perfect fragment of any of the bones of the extremities appears to be the distal end of a humerus. It presents a division into two condyles by wide and shallow anterior and posterior depressions, and the width of the bone in this part, when perfect, could hardly have been less than five inches. It narrows very rapidly, however, and where it is broken, at 3·5 in. from the dorsal end, its

shaft is not more than 1·7 in. wide and as much in antero-posterior diameter. It has a large medullary cavity, the bony walls of which are on the average not more than 0·3 in. thick.

From the general resemblance of the dermal armour and teeth of this reptile to those of *Scelidosaurus*, *Hylæosaurus*, and *Polacanthus*, it plainly belongs to the same group; but its teeth separate it from the first genus, and the characters of its dermal armour from the two latter. I propose to call it *Acanthopholis horridus*.

My colleague Mr. Etheridge is good enough to supply me with the following precise determination of the stratigraphical position of the remains. I may add that numerous portions of *Ichthyosaurus campylodon* have been obtained by Mr. Griffiths "about six feet lower down" than *Acanthopholis*.

EXPLANATION OF PLATE V. [PLATE 22].

Acanthopholis horridus, Huxley.

Fig. 1. *a*. Side view of one of the spine-like scutes: *b*. Front view of the same.

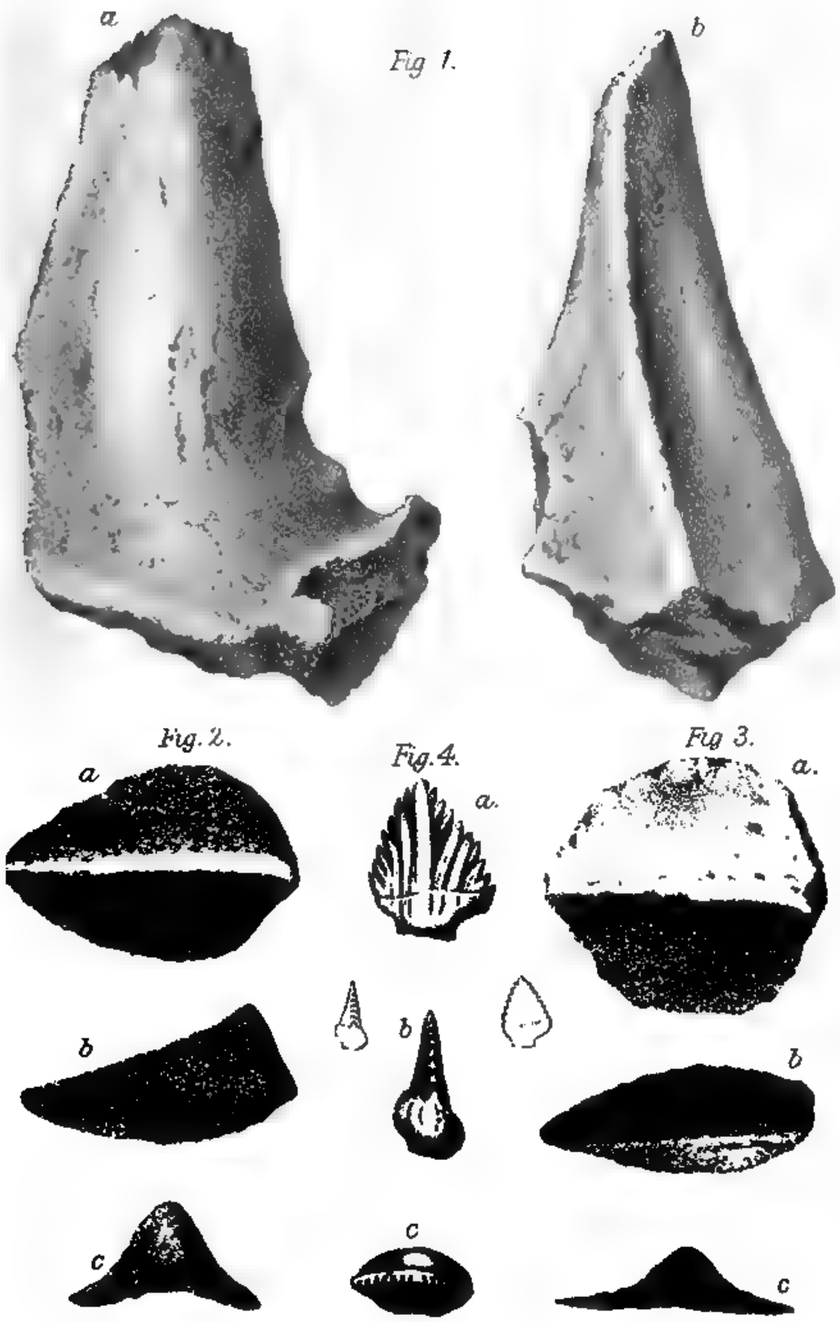
Fig. 2. *a*. A more depressed scute seen from above; *b*. viewed laterally; *c*. viewed from the hinder, or more raised, end.

Fig. 3. *a*. A still flatter scute seen from above; *b*. viewed laterally; *c*. viewed from the hinder end.

(The preceding figures are one-half the size by nature.)

Fig. 4. *a*. A tooth viewed from one side; *b*. with one edge turned to the eye; *c*. from above.—The outlines give the natural size of the tooth.

[PLATE 22]



Wilde. del. A. Hammond. Lith.

ACANTHOPHOLIS HORRIDUS.
Chalk Marl, Folkestone.

ON THE STRATIGRAPHICAL POSITION OF *ACANTHOPHOLIS HORRIDUS* (HUXLEY).

By ROBT. ETHERIDGE, Palæontologist to the Geological Survey of Great Britain.

The Geological Magazine, vol. iv., 1867, *pp.* 67–69.

PROFESSOR HUXLEY'S communication, relative to the discovery of a new Reptile in the Lower Chalk of the South of England, which he has called *Acanthopholis horridus*, may be rendered more interesting by a detailed description of its stratigraphical position and its associated organic remains, a matter of some importance in this case, as few, if any, higher reptilian remains have occurred in the Lower Chalk of either Europe or England; whereas in the Wealden group below the true Cretaceous rocks, and still lower, in the Oolites and Lias, many genera occur. The discovery by the Rev. W. Fox of a remarkable and allied reptile in 1866, from the Wealden beds of the Isle of Wight, named *Polacanthus* by Professor Owen, increases still more the interest of this new genus, and is another reason why it is well to understand its geological horizon.

The remains were found in the autumn of the past year in the lower part of the Chalk Marl immediately east of Copt Point, Folkestone. The beds of the Lower Chalk here are much disturbed and pushed out of place, owing, doubtless, to the unctuous nature of the Gault which underlies the sandy Upper Greensand; and the Lower Hard Chalk, owing to its great superincumbent weight, has slid over and here pressed up the Gault and Upper Greensand seaward, thus giving a faulted appearance along a line from east to west; it is, however, superincumbent pressure only that has produced the crumpling and apparently reversed dip of the Gault, Upper Greensand, and the lower members of the Chalk. The

true position of the whole series is admirably exhibited and easily understood along the shore to the eastward under Lyddon's Spout, etc.

The sequence of the beds near Copt Point, where the Reptilian remains were found, was at first difficult clearly to understand, from the circumstance of their occurring between high and low water mark, and the denuding agency of the sea, along the strike, or exposed edges of the beds which dip north, or towards the cliff, is constantly destroying the soft Upper Greensand and yielding Lower Chalk.

I was, however, enabled clearly to determine the true place of the fossil, and also its associated fauna. From the same bed I listed no less than forty species, comprising *Amorphozoa*, *Echinodermata*, *Mollusca*, and the remains of another reptile, *Ichthyosaurus campylodon*.

At Copt Point the Gault may be about 100 feet in thickness, preceded by (when moist) the dark-green sandy Upper Greensand, which is from fifteen to twenty feet thick, and at the upper part cuts a bright copper-green colour. This Upper Greensand is immediately succeeded by the hard, dense, pale-grey Chalk Marl, which becomes nearly white when deprived of its moisture. It was in the lower part of this, and about eight feet above the Upper Greensand, that the remains of *Acanthopholis horridus* were found by Mr. Griffiths, portions of which ultimately came into Professor Huxley's possession through Dr. Percy: their affinities were immediately recognised, but the characters being different to any known genus no pains were spared to obtain as much as possible of the remaining skeleton, and, although in a fragmentary state, yet enough has been obtained to establish the genus.

My attention, on visiting the section, was immediately turned to the associated fossils, which clearly determine the age and position of the remains, and definitely fix it as belonging to the lower part of the Grey Chalk series, (the Chalk Marl with *Brachiolithes*) and the remains of *Ichthyosaurus campylodon* and *Saurocephalus lanciformis* occurred in the same bed, numerous teeth of both genera being found. Many well-marked species of *Cephalopoda*, peculiar to this lower zone of the Chalk Marl, occur in the same matrix, viz., *Ammonites Rothomagensis*, Brong.; *Am. navicularis*, Mant.; *Am. Mantelli*, Sow.; and *Am. varians*, Sow.; which last species has a wider range in time and space than the other three. The non-involuted sinistral *Ammonitidæ*, represented by *Turrilites costatus*, Lam.; *T. tuberculatus*, D'Orb.; *T. undulatus*, Sow. (*Scheuchzerianus*,

Bosc.); and *Scaphites æqualis*, occur plentifully, accompanied by *Nautilus elegans*, Sow. and *N. pseudoelegans*, D'Orb.; *Terebratulina striata*, Schloth. (*rigida*, Sow.), *Terebratula biplicata*, Broch.; *T. obesa*, Sow., were the only species noticed as coming from that particular horizon. *Pleurotomaria perspectiva*, Mant.; *P. rhodani*, Brong., the latter peculiar to the Lower Chalk, occurs but sparingly, and chiefly in the form of casts. The associated bivalves of the group *Asiphonida*, are *Ostræa carinata*, Sow.; *Plicatula inflata*, Sow.; *P. pectinoides*, Sow.; *Inoceramus mytiloides*, Mant.; *Exogyra*, *Pecten orbicularis*, Sow., and casts of other species; and only one genus of the *Siphonida*, viz., *Pholadomya decussata*, was observed amongst them. Of the *Echinodermata* fragments of *Goniaster Coombii* or *G. mosaicus*, Forbes; *Peltastes clathrata*, Aq.; *P. umbrella*, Aq.; *Discoidea subucula*, Klein; *Holaster subglobosus*, Leske; *Pseudodiadema* (*Diadema*) resembling *variolare*, but eroded; and an *Hemiaster;* also club-shaped spines of *Cidaris.* All these species occur in the Chalk Marl along the shore, and are obtainable from fallen masses Several *Amorphozoa*, such as *Chenendopora fungiformis*, *Brachiolithes labrosus*, and another species, are plentiful in places. This singular genus of Ventriculites forms the chief mass of the lower part of the bed in which the Reptilian remains occur. *Vermicularia* is the only annelide noticed.

The above organic remains were found associated with *Acanthopholis* in the same matrix, and they tend not only to elucidate the contemporaneous or co-existing fauna, but also to give exactness to the determination of its age. Whether the habits of *Acanthopholis* resembled the *Scelidosaurus* of the Lias, or the *Hylæosaurus*, and *Iguanodon* of the Wealden, future research may more definitely determine. We cannot, however, fail to notice that in this new form another link is added to the persistency of type preserved through so long a period of time, and through those numerous geological changes which occurred during the deposition and succession of the lower, middle, and upper oolitic rocks, as well as the Wealden and Cretaceous formations. It is to be regretted that the skeleton should have been so dismembered, but the unyielding nature of the matrix, which is tough, much jointed, and possesses that conchoidal fracture peculiar to hard marly deposits, rendered it almost impossible to remove it in any other way than piece by piece, and it was so incorporated with the remains that none but an experienced workman could have succeeded in relieving even so much as is preserved to us.

XIII

ON THE CLASSIFICATION OF BIRDS; AND ON THE TAXONOMIC VALUE OF THE MODIFICATIONS OF CERTAIN OF THE CRANIAL BONES OBSERVABLE IN THAT CLASS.

Proceedings of the Scientific Meetings of the Zoological Society of London, 1867. *pp.* 415–472. (*Read April 11th*, 1867.)

THE members of the class AVES so nearly approach the REPTILIA in all the essential and fundamental points of their structure, that the phrase "Birds are greatly modified Reptiles" would hardly be an exaggerated expression of the closeness of that resemblance.

In perfect strictness, no doubt, it is true that Birds are no more modified Reptiles than Reptiles are modified Birds, the reptilian and the ornithic types being both, in reality, somewhat different superstructures raised upon one and the same ground-plan; but it is also true that some Reptiles deviate so very much less from that ground-plan than any Bird does, that they might be taken to represent that which is common to both classes, without any serious error. A Lizard is not very far from being the centre of the circle, the periphery of which is occupied by Chelonia, Ichthyosauria, Plesiosauria, Pterosauria, and Aves.

That the association of Birds with Reptiles into one primary group of the Vertebrata, the SAUROPSIDA, which I have proposed elsewhere, is not a mere fancy, but that the necessity of such a step is as plain and demonstrable as any position in taxonomy can be, appears to me to be proved by an enumeration of the principal points in which Aves and Reptilia agree with one another and differ from Mammalia.

1. They are devoid of hair.
2. The centra of their vertebræ have no epiphyses.

3. Their skulls have single occipital condyles.

4. The prootic bone either remains distinct throughout life, or unites with the epiotic and opisthotic *after* these have become anchylosed with the supraoccipital and exoccipital.

5. The *incus* and *malleus* are not subservient to the function of hearing as *ossicula auditus*.

6. The mandible is connected with the skull by the intermediation of a quadrate bone (which represents the *incus* of Mammalia).

7. Each ramus of the mandible is composed of a number of separate ossifications, which may amount to as many as six in all. (Of these the *articulare* represents the *malleus* of Mammalia).

8. The apparent "ankle-joint" is situated not between the *tibia* and the *astragalus* as in the Mammalia, but between the proximal and the distal divisions of the *tarsus*.[1]

9. The brain is devoid of any *corpus callosum*.

10. The heart is usually provided with two aortic arches; if only one remains, it is the right.

11. The red blood-corpuscles are oval and nucleated.

12. The cavities of the thorax and abdomen are never separated by a complete diaphragm.

13. The allantois, which is highly vascular, is very large, and envelopes the embryo; but no villi for placental connexion with the parent are developed upon it.

14. There are no mammary glands.

I attach less weight to the first of these characters than to the rest, since the simpler kinds of feathers very closely approach hair in structure and development; but the other thirteen are, for the most part, of extreme importance, and define Birds and Reptiles, as a whole, very sharply from Mammals.

Closely as Birds approach Reptiles, however, and small as the divergence of the ornithic type from the reptilian appears to be, in view of the great divergences of Reptiles from one another, there are still a number of characters common to Birds which are absent in all recent Reptilia, and, so far as our knowledge goes, in extinct Reptiles—though it must be carefully borne in mind that our information respecting the latter is limited to an acquaintance with their osteology. Thus—

1. Birds possess epidermal appendages developed in sacs of the dermis, and having the structure of feathers.

[1] See Gegenbaur, "Archiv für Anatomie" (1863), and "Untersuchungen zur vergleichenden Anatomie" (1864).

2. More or fewer of the anterior vertebræ have centra with cylindroidal articular surfaces.[1]

3. Although all birds possess a remarkably large sacrum, the vertebræ, through the intervertebral foramina of which the roots of the sacral plexus (and, consequently, of the great sciatic nerve) pass, are not provided with expanded ribs abutting against the ilium externally, and against the bodies of these vertebræ by their inner ends.

In recent Reptiles, possessing well-developed hind-limbs, the intervertebral foramina through which the roots of the sciatic nerve pass[2] are wholly, or in part, bounded by vertebræ provided with thick and expanded ribs; and these ribs are connected, more or less extensively, on the one hand, with the bodies of these vertebræ, and on the other with the iliac bones. The vertebræ in question, of which there are ordinarily two, constitute the sacrum. In Birds the arches of the vertebræ which correspond with these in their relation to the nerves (and therefore must also be termed "sacral") give off comparatively slender transverse processes, which seem to answer to those which unite with the tubercles of the ribs in the dorsal region; and it is by these transverse processes only that they are connected with the ilia.

4. The broad and expanded part of the sternum, which immediately follows the coracoidal articular surfaces, receives all the sternal ribs. In all recent Reptilia which possess sternal ribs, some of the latter articulate with narrow prolongations, which extend back from the posterior angle of the expanded rhomboidal sternal plate. The sternum in Birds ossifies in a manner which has not been observed in any Reptile.

6. The ischia never unite in a median ventral symphysis; and both pubes and ischia are directed backwards, approximately parallel with one another and with the spinal column.

7. The proximal constituent of the tarsus is anchylosed with the

[1] *Archæopteryx* may possibly prove an exception to this rule. When certain of the vertebræ of Birds (as in the Penguins, *Larus fuscus*, and others) have centra with spheroidal articular surfaces, the anterior faces of the centra are convex and the posterior concave, which is the rarest case among the Reptilia. The procœlous form of vertebra, so common among the Reptilia, has not been observed in the cervical or dorsal regions of the spine of Birds.

[2] The sciatic nerve of the Crocodile is formed, for the most part, by a root which leaves the spinal canal by the intervertebral foramen, interposed between the two sacral vertebræ, and which passes between the two expanded sacral ribs. It receives a large accessory branch from the preceding, and a smaller from the succeeding, spinal nerve. In *Gecko verus* the root of the sciatic nerve, which passes out between the two sacral vertebræ, is smaller than that which lies in front of it, between the anterior sacral and the last lumbar vertebræ.

tibia into one tibio-tarsal bone;[1] the distal element of the tarsus similarly unites with the second, third, and fourth metatarsal bones, and gives rise to the tarso-metatarsal bone. The metatarsal of the hallux is shorter than the others, and does not reach the tarsus.

Unless, as Gegenbaur has rendered probable, the hind limb of the extinct reptile *Compsognathus* was similarly modified, these characters are diagnostic of birds. In any case they are highly characteristic of them.

8. Birds have hot blood, a muscular valve in the right ventricle, a single aortic arch, and remarkably modified respiratory organs; but it is, to say the least, highly probable that the Pterosauria, if not the Dinosauria, shared some of these characters with them. The amount of work involved in sustaining a Pterodactyle in the air would seem, physiologically, to necessitate proportional oxidation and evolution of waste products in the form of carbonic acid. If so, a proportional quantity of heat must have been evolved, and there must have been a ready means of eliminating the carbonic acid from the blood. We know of no such means, except those which are afforded by highly developed circulatory and respiratory organs; and therefore it is highly probable that the Pterodactyles had more perfect organs of this kind than their congeners, accompanied by the correlative hot blood.

But since we know that the organs of respiration and circulation of a Bat are very different from those of a Bird, it is quite possible that those of a Pterodactyle may have been different, in detail, from either.

Having thus arrived at the conclusion that the class Aves, while well enough defined from all existing Reptiles, is nevertheless far more closely connected with the class Reptilia than with any other, I proceed to inquire how Birds may be subdivided into orders, suborders, and families, by characters equalling, or at any rate approaching, in definiteness those which mark out the corresponding groups among Mammals and Reptiles.

I propose to divide the class Aves into three orders: the SAURURÆ, the RATITÆ, and the CARINATÆ.

I. The SAURURÆ (Haeckel) are represented by the solitary fossil *Archæopteryx*, which seems to have been distinguished from all other birds by the following characters:—

1. The metacarpal bones are well developed, and are not anchylosed together.

[1] See Gegenbaur, *l. c.*

2. The caudal vertebræ are both numerous and large, so that the caudal region of the spine is longer than the body, whereas in all other birds it is shorter than the body.

The furculum is complete and strong, and the foot extremely passerine in appearance. The forms of the skull and of the sternum are unknown.[1]

II. The RATITÆ (Merrem), or the Struthious Birds, differ from all others in the combination of the following peculiarities :—

1. The sternum is devoid of a crest, and ossifies only from lateral and paired centres.

2. The long axes of the adjacent parts of the scapula and coracoid are parallel or identical.[2] The scapula has no acromial process, nor has the coracoid any clavicular process ; at most there are inconspicuous tubercles representing these processes.

3. The posterior ends of the palatines and the anterior ends of the pterygoids are very imperfectly, or not at all, articulated with the basisphenoidal rostrum, being usually separated from it, and supported by the broad, cleft, hinder end of the vomer.

4. Strong "basipterygoid" processes, arising from the body of the basisphenoid and not from the rostrum, articulate with facets which are situated nearer the posterior than the anterior ends of the inner edges of the pterygoid bones.

5. The upper, or proximal, articular head of the quadrate bone is not divided into two distinct facets.

6. The barbs of the feathers are disconnected.

7. There is no inferior larynx, and the diaphragm is better developed than in other birds.

Though comparatively but few genera and species of this order now exist, they differ from one another very considerably, and have a wide distribution, from Africa and Arabia over many of the islands of Malaisia and Polynesia to Australia and South America. Hence, in all probability, the existing Ratitæ are but the waifs and strays of what was once a very large and important group.

The Afro-Arabian genus *Struthio* is the type of one group of this order, characterised by :—

[1] The "retention of two unguiculate digits on the radial side of the metacarpo-phalangeal bones modified for the attachment of the primary quill-feathers" (Philosophical Transactions, 1863, p. 46) is no distinctive character of *Archæopteryx*, both *Struthio* and *Rhea* presenting "two unguiculate digits" in the manus.

[2] My friend Professor Newton informs me he had already drawn attention to this important point in his Lectures delivered at Cambridge last autumn.

1. The prolongation of the maxillary processes of the palatine bones forwards, beneath the maxillo-palatines,[1] as in most birds.

2. The thickening of the inner edges of the maxillo-palatines, and their articulation with facets upon the sides of the vomer.

3. The shortness of the vomer, which does not articulate with either palatines or pterygoids posteriorly.

4. The slight, or wanting, ossification of the prefrontal processes of the primordial cranium.

5. The union of the bodies of the sacral vertebræ with the anterior ends of the pubes and ischia.

6. The presence of two shallow notches, on each side, in the posterior margin of the sternum.

7. The proportions of the fore limb. The humerus is about equal in length to the distance between the pectoral arch and the ilium, and is therefore much longer than the scapula. The antebrachium is not half as long as the humerus. The manus possesses the ordinary three digits; and two of these, the radial and the middle, are provided with claws.[2]

8. The union of the pubes in a symphysis.

9. The abortion not only of the hallux, but also of the distal

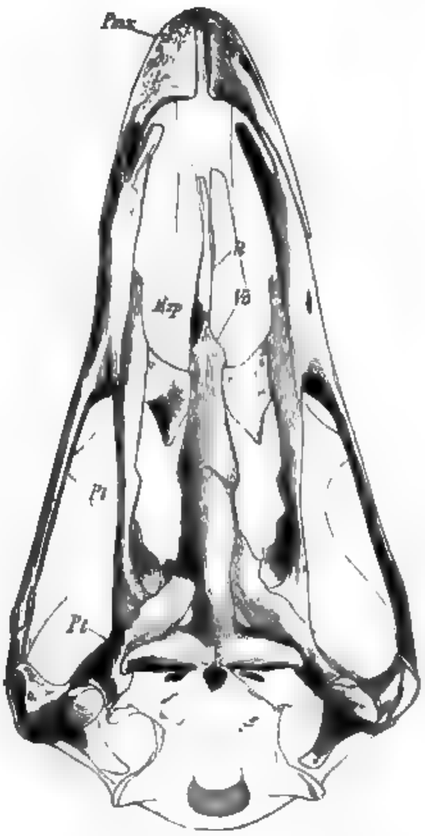


FIG. 1.—Under view of the skull of *Struthio camelus*. From a specimen in the Museum of the Royal College of Surgeons.

Pmx. The præmaxillæ. *R*. The sphenoidal rostrum. *Vo*. The vomer. *Pl*. The palatine bone. *Mxp*. The maxillo-palatine plate of the maxillary. *Pt*. The pterygoid.

[1] By the term "*maxillo-palatines*" I designate those processes of the maxillary bones which extend, more or less horizontally, inwards and contribute to the formation of the roof of the mouth and the anterior and inferior walls of the nasal chambers. Nitzsch called them "Muscheltheile." Mr. Parker has included them, with the maxillæ of which they form a part, under the head of *prevomers*. I conceive these maxillo-palatine processes to answer to the palatine processes of the maxillary bones in the Mammalia.

[2] This interesting fact was first noted by Nitzsch ("Osteografische Beiträge," p. 91), but has since been forgotten.

end of the metatarsal bone and of the phalanges of the second digit of the foot, whence the foot is two-toed.

10. The presence of thirty-five precaudal[1] vertebræ.

11. The feathers being devoid of aftershafts.

A second group is represented by the South American genus *Rhea*, in which—

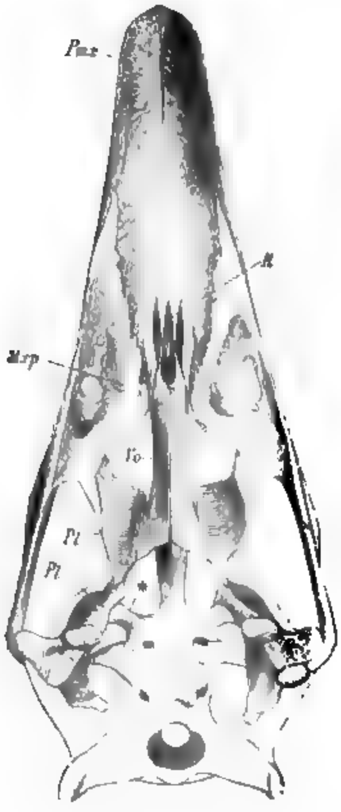


FIG. 2.—Under view of the skull of *Rhea americana*.

Pmx. The premaxilla. *R*. The rostrum. *Mxp*. The maxillo-palatine. *Vo*. The vomer. *Pl*. The palatine. *Pt*. The pterygoid. * The basipterygoid process of the sphenoid.

1. The maxillary processes of the palatines are short, and unite with the inner and posterior edges of the maxillo-palatines.

2. The maxillo-palatines are thin, fenestrated plates, which do not articulate with facets on the edges of the vomer.

3. The vomer is as long as it usually is in birds, and articulates behind with the palatine and pterygoid bones.

4. The prefrontal processes are little ossified.

5. The bodies of the proper sacral vertebræ do not unite with the pubes or ischia ; and the centra of the sacral vertebræ, which ossify late, are extremely elongated and slender.

6. The short sternum narrows posteriorly, and presents a notch in the middle of its posterior edge.

7. The length of the humerus exceeds the distance between the shoulder-girdle and the ilium, and is of course greatly longer than the scapula. The manus has the same conformation as that of *Struthio*.

8. The pubes are free ; but the ischia unite beneath the urosacral[2] vertebræ.

[1] I regard as "caudal" all those vertebræ of the bird's complex "sacrum" which lie behind the exit of the roots of the sacral plexus. The foremost of these caudal vertebræ are readily distinguished from the proper sacral vertebræ, which immediately precede them, by possessing inferior transverse processes, or, more strictly speaking, anchylosed ribs, which, like flying buttresses, pass from the bodies of the vertebræ upwards and outwards to the roof of the "sacrum" at its junction with the ilium.

[2] I term "urosacral" those caudal vertebræ which unite with one another and with antecedent vertebræ to form the "sacrum" of a bird.

9. The hallux is absent ; but the second, third, and fourth digits are complete.

10. There are only thirty-two precaudal vertebræ.

11. The feathers are devoid of an aftershaft.

The Malayo-Australian genera *Casuarius* and *Dromæus* are members of a third group, which may be defined as follows :—

1. The maxillary processes of the palatines are short, as in *Rhea*.

2. The maxillo-palatines are flat, imperforate plates, which unite solidly with the premaxillæ and the vomer.

3. The vomer is long, and articulates behind with the palatine and pterygoid bones.

4. The prefrontal processes are large and well ossified.

5. The bodies of the proper sacral vertebræ do not unite with the pubes or ischia ; and the bodies of the urosacral vertebræ are very large, thick, and well ossified.

6. The sternum is long and escutcheon-shaped, at first widening and then coming to a point behind.

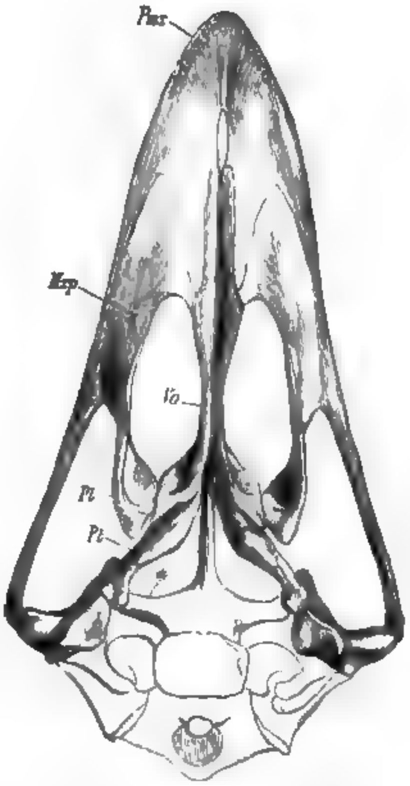


FIG. 3.—Under view of the skull of *Dromæus novæ-hollandiæ*. (From a specimen in the Museum of the Royal College of Surgeons.) The letters have the same signification as in the preceding figures.

7. The humerus is not nearly half so long as the distance between the pectoral arch and the ilium, and is much shorter than the scapula. The antebrachium is not more than half as long as the humerus. Only one digit, the median, is complete and bears a claw.

8. Neither the pubes nor the ischia unite in the middle line of the body.

9. The hallux is absent, but the other digits are complete.

10. There are thirty-five precaudal vertebræ.

11. The feathers have aftershafts as long as the principal shafts.

The extinct *Dinornis* of New Zealand differs from the other Ratitæ, and thus represents a fourth group, in exhibiting :—

1. A skull with high arched beak and projecting occipital condyle.
2. Flat, imperforate maxillo-palatine plates, which unite solidly with the premaxillæ and probably with the vomer, as in *Dromæus*.
3. A Dromæine pelvis.
4. A broad sternum with two posterior notches.
5. A very rudimentary pectoral arch, which appears to have possessed no glenoidal cavity for the articulation of the humerus.
6. Three toes, the hallux being absent.
7. The feathers have an aftershaft.[1]

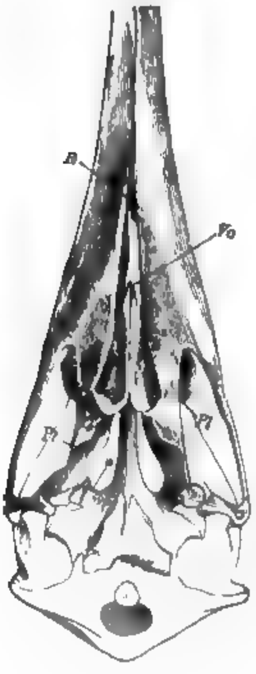


FIG. 4.—Under view of the skull of *Apteryx australis*. From a specimen in the Museum of the Royal College of Surgeons.
The letters as before.

Lastly, the remarkable living New Zealand genus *Apteryx* represents a fifth division, having :—

1. The palatines short and broad, and uniting by an oblique suture with the expanded maxillo-palatines, which are flat, imperforate plates uniting with the premaxillaries and the vomer.
2. The vomer long and uniting with the palatines and pterygoids posteriorly.
3. The prefrontal processes very large and spongy.
4. The bodies of the proper sacral vertebræ not united with the ischia or pubes ; the urosacrals large and well ossified.
5. The sternum broad and with two posterior excavations.
6. The humerus longer than the scapula, and extending for about half the distance between the pectoral arch and the ilium. The antebrachium about half the length of the humerus, and the manus possessing but one claw.
7. Neither the pubes nor the ischia united in the middle line of the body ; nor are the pubis and the ischium of the same side united by bone.
8. The hallux present, as well as the other three digits of the foot.
9. Only thirty-two precaudal vertebræ.
10. The feathers without any aftershaft.

[1] See Dallas, Proceedings of the Zoological Society, 1865.

It will be observed that in each of these families of the Ratitæ a particular form and arrangement of the bones of the palate accompany the other distinctive characters.

III. The order CARINATÆ (Merrem) embraces all existing birds, except the Ratitæ. They have the following characters in common:—

1. The sternum possesses a keel, and ossifies from a median centre in that keel, as well as from lateral paired centres.[1]

2. The long axes of the adjacent parts of the scapula and coracoid make an acute or a slightly obtuse angle, and are never, even approximately, identical or parallel.[2] The scapula always has a distinct acromion and the coracoid a clavicular process.

3. The vomer is comparatively small, and allows the pterygoids and palatines to articulate directly with the basisphenoidal rostrum.[3]

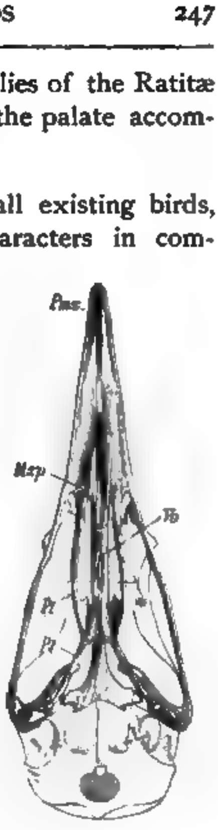


FIG. 5.—Under view of the skull of *Tinamus robustus*. From a specimen belonging to W. K. Parker, Esq., F.R.S.

The letters as before, except * the prefrontal, and + the basipterygoid, process.

In this order the bones which enter into the formation of the palate are disposed in four different modes, which may be called respectively the *Dromæognathous*, *Schizognathous*, *Desmognathous*, and *Ægithognathous* arrangement.

I. The *Dromæognathous* Birds are represented by the single genus *Tinamus*, which (as Mr. Parker has shown[4]) has a completely struthious palate. In fact the vomer is very broad, and in front unites with the broad maxillo-palatine plates, as in *Dromæus*; while behind it receives the posterior extremities of the palatines and the anterior ends of the pterygoid bones, which thus are prevented, as in the Ratitæ, from entering into any extensive articulation with the basisphenoidal rostrum.

[1] The sternum is thus ossified in all the Carinatæ which have yet been examined. The only apparent exception to the presence of a keel is the singular genus *Strigops*. A knowledge of the ossification of the sternum of this bird is greatly to be desired.

[2] The only genera in which, so far as I know, this angle is somewhat greater than a right angle are *Ocydromus* and *Didus*.

[3] *Tinamus* perhaps affords an exception to this character.

[4] "On the Osteology of the Gallinaceous Birds and Tinamous" (Transactions of the Zoological Society, vol. v., 1864). Sundevall, however, had already said of *Tinamus*, *Rhynchotus*, and *Crypturus*, "Struthiones parvos referunt."

The basipterygoid processes spring from the body of the sphenoid, not from its rostrum, and they articulate with the pterygoids very near the distal, or outer, ends of the latter bones. The head of the quadrate bone is single, as in the Struthious birds (Parker, *l. c.*).

But the sternum of *Tinamus* has a great crest, and the coracoid and scapulæ have the arrangement and structure usual in the Carinatæ. And though the ischium is not united with the ilium by bone behind the acetabulum, so that the sciatic notch is not converted into a foramen by bone, this character is not universal among the Ratitæ, and, in *Tinamus*, a fibrous or cartilaginous bridge does connect the two bones.

Though the most Struthious of all Carinate birds, then, *Tinamus* cannot, I think, be removed from the order of the Carinatæ.

II. In the large assemblage of birds belonging to the Cuvierian orders Gallinæ, Grallæ, and Natatores, which may be termed *Schizognathous*, the vomer, sometimes large and sometimes very small, always tapers to a point anteriorly; while posteriorly it embraces the basisphenoidal rostrum, between the palatines. But the latter bones and the pterygoids are directly articulated with one another and with the basisphenoidal rostrum, and are not borne by the divergent posterior ends of the vomer.

The maxillo-palatines are usually elongated and lamellar; they pass inwards over the anterior processes of the palatine bones, with which they become united, and then bending backwards, along the inner edge of the palatines, leave a broader or a narrower fissure between themselves and the vomer, and do not unite with it or with one another.

This Schizognathous arrangement of the palatine bones is extremely well displayed by the Plover, as the accompanying figure of the parts in *Charadrius pluvialis* shows.

The palatine bone (fig. 6, *Pl*) presents an expanded part, which may be called its "*body*," the inner and outer edges of which are produced into internal and external "*laminæ*," separated by a longitudinal groove or depression. In this bird the outer lamina descends much further than the inner. The free edge of the outer lamina joins the posterior margin nearly at a right angle, and thus gives rise to the "*postero-external angle.*" The postero-internal angle of the body of the bone is produced into a "*pterygoid process*," which articulates with the pterygoid posteriorly, and with the basisphenoidal rostrum internally. Superiorly the body of the palatine bone passes into what may be termed its "*ascending process*" which bends

round so as to form the posterior boundary of the nasal passage, and ends, on the inner side of that passage, in a slender prolongation which passes forwards and applies itself to one of the forks of the vomer (fig. 8, *Vo*).

Anteriorly the body of the palatine gradually narrows into its "anterior" or "*maxillary process*," the origin of which is coincident with the abrupt termination of the inner lamina. The slender anterior extremity of this process coalesces with the maxillary and premaxillary bones of its own side. The vomer is deeply cleft behind, and embraces the sphenoidal rostrum by its two slender forks (fig. 8). In front it becomes flattened and slightly decurved (fig. 7), ending in a point opposite the level of the union of the palatines with the maxillaries and premaxillaries. Immediately behind the place at which the maxilla (*Mx*) gives off its ascending process to join the external descending process of the nasal (*Na*), it sends a slender stem of bone inwards; and this almost immediately expands into the oval, scroll-

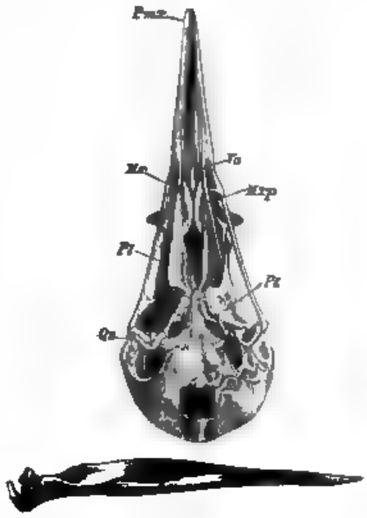


FIG. 6.—The inferior face of the skull, and a lateral view of the outer side of the right ramus of the mandible, of *Charadrius pluvialis*; of the size of nature.

Pmx. The premaxilla. *Mx*. The maxilla. *Mxp*. Its maxillo-palatine process. *Pl*. The palatine bone. *Pt*. The pterygoid bone. *Qu*. The quadrate bone. × The basipterygoid process.

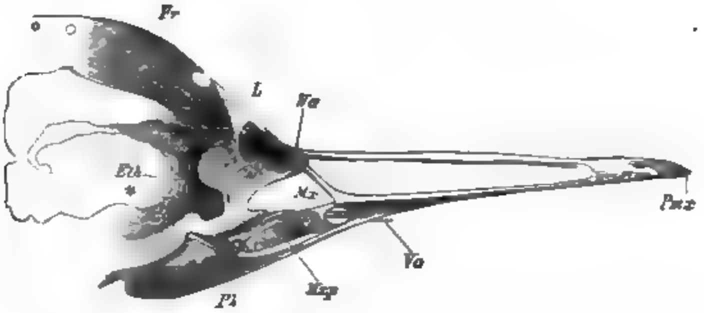


FIG. 7.—A side view of the fore part of the skull of *Charadrius pluvialis*, enlarged.
Pmx, *Mx*, *Mxp*, *Pl*, as before. *Na*. The nasal bone. *Fr*. The frontal. *Eth*. The ethmoid. *L*. The lachrymal. * The ossified prefrontal process of the ethmoidal cartilage, which separates the orbital from the nasal chamber.

like, maxillo-palatine plate (*Mxp*), the convex face of which looks upwards and inwards, while its concave face looks downwards and

outwards. The maxillo-palatine has an abruptly truncated posterior free edge, while in front it tapers off and becomes united with the upper surface of the maxillary process of the palatine (fig. 8). In the middle line, its rolled edge, which lies on the inner side of the maxillary process, comes very near that of its fellow; but it remains perfectly distinct from the other maxillo-palatine and from the vomer. The plate is perforated by four holes, between which a sort of St. Andrew's cross of bone is left (fig. 8).

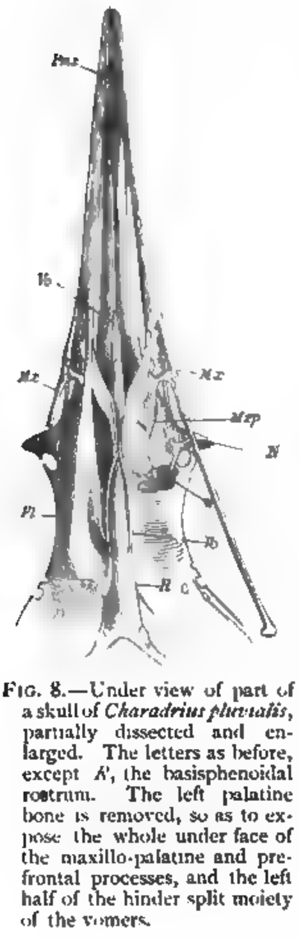


FIG. 8.—Under view of part of a skull of *Charadrius pluvialis*, partially dissected and enlarged. The letters as before, except *R'*, the basisphenoidal rostrum. The left palatine bone is removed, so as to expose the whole under face of the maxillo-palatine and prefrontal processes, and the left half of the hinder split moiety of the vomers.

It follows from this description that, in the dry skull of the Plover, the blade of a thin knife can be passed, without meeting with any bony obstacle, from the posterior nares alongside the vomer to the end of the beak.

On each side of its commencement the basisphenoidal rostrum presents a small elevation, terminated by a flat oval facet (fig. 6, ×) which represents the basipterygoid process of the Ratitæ. A corresponding facet on the inner edge of the pterygoid bone, nearer its anterior than its posterior end, articulates with this (fig. 6).

The angle of the mandible is elongated into a slender process, which bends abruptly upwards, and is frequently broken off (fig. 6).

The Pluvialine form and arrangement of the maxillary, palatine, and pterygoid bones just described are substantially repeated in the following Pressirostres and Longirostres of Cuvier: — *Charadrius, Œdicnemus, Vanellus, Hæmatopus, Cursorius, Scolopax, Numenius, Rhynchæa, Limosa, Tringa, Machetes Phalaropus, Strepsilas, Totanus, Himantopus.*

The Cranes almost always lack basipterygoid processes and the corresponding facets upon the pterygoids, the only exception I have met with being *Grus antigone.* The Rails are always devoid of basipterygoid processes. In other points the palates of these birds, of *Eurypyga*, of the Kagu, of *Psophia*, and of *Otis* are similar to that

of the Plover. The angle of the mandible, however, is obliquely truncated, and not produced into an upwardly curved process.

In the Gulls, the Divers, the Grebes, the Auks, and the Penguins, the bones which form the roof of the mouth have the same general arrangement and form as in the Plovers. But they are devoid of basipterygoid processes; and in the Penguins the pterygoids become much flattened from above downwards.

But the *Procellariidæ* differ from the families which have just been enumerated in the great expansion of the maxillo-palatines, which become thick and spongy, and so closely approach the middle line that, in the Albatroses, only a very narrow cleft is left on each side of the vomer.

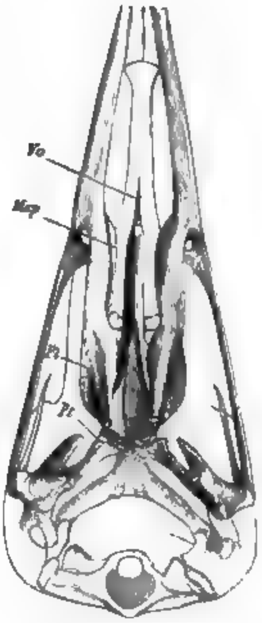


FIG. 9.—Under view of the skull of *Grus pavonia*. From a specimen in the Museum of the Royal College of Surgeons.

The letters as before.

The front part of the vomer itself is much more strongly bent downwards than in the Gulls; and the ascending process of the palatine bone is greatly produced, and becomes anchylosed with the vomer.

Procellaria gigas holds a sort of middle place between the Gulls and the Albatroses, the maxillo-palatines being less swollen, and the clefts between them and the vomer far larger than in *Diomedea*. In this species again the basipterygoid processes are present, though I have not been able to observe them in other *Procellariidæ*.

Among the Gallinaceous Birds, the *Phasianidæ*, *Turnicidæ*, and *Pteroclidæ* all have basipterygoid processes, which are situated upon the rostrum, and take the form of sessile, oval, articular facets for the pterygoid bones. The palatine bones have long and slender anterior processes, and completely rounded off postero-external angles. They have generally small, and sometimes almost obsolete, maxillo-palatines, and very imperfectly developed vomers, so that the vomero-palatine clefts are wide and, usually, almost uninterrupted, throughout their length, which is, relatively, very considerable.

The angle of the mandible is prolonged and bent upwards, sometimes, as in *Tetrao*, acquiring a prodigious length.

In the *Megapodidæ* (e.g. *Talegalla*) the maxillo-palatines take the form of thin plates tapering to their free ends, which pass inwards,

and then, before they reach one another, bend back at a right angle. The basipterygoid processes are as in the preceding genera; and the mandible has a strong recurved angular process.

In the *Cracidæ* the characteristic basipterygoid processes, the produced and recurved angle of the mandible, and the form of the palatines remain as in the last-mentioned genera. But the maxillo-palatines are large and scroll-like, stretching inwards, and in some

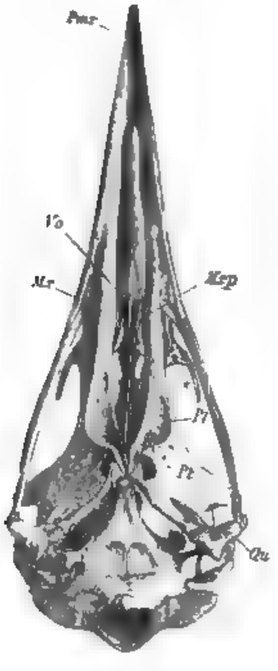


FIG. 10.—*Alca torda.*

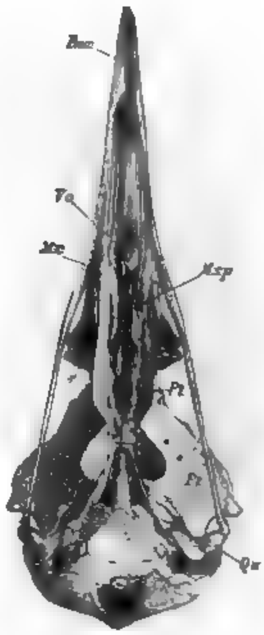


FIG 11.—*Larus rissa.*

Views of the inferior aspect of the skull in *Alca torda* (fig. 10) and *Larus rissa* (fig. 11), of the size of nature. The letters have the same signification as in the figures of *Charadrius*, a comparison with which will bring out the fundamental resemblance of the three skulls better than a description can do.

species (e g. *Crax globicera*) even becoming united across the middle line with one another and with a small ossification of the *septum narium.*

All *Columbidæ* (except *Didus*) have basipterygoid processes, and are completely Schizognathous. The maxillo-palatines are larger than in the ordinary Gallinaceous birds, and are elongated from before backwards, and spongy in texture, not scroll-like. The postero-external angles of the palatine bones are rounded off; but, in most of the *Columbidæ*, their inner laminæ are more prominent than the outer, instead of being obsolete as in the Gallinaceous birds. The

basipterygoid processes are prominent and rather resemble those of the Plovers than those of the last-named group. Finally, the angle of the mandible is neither produced nor recurved, but is more or less abruptly truncated. The vomer is very slender.

Didus has no basipterygoid processes; but the articular end of its mandible resembles that of other *Columbidæ*.

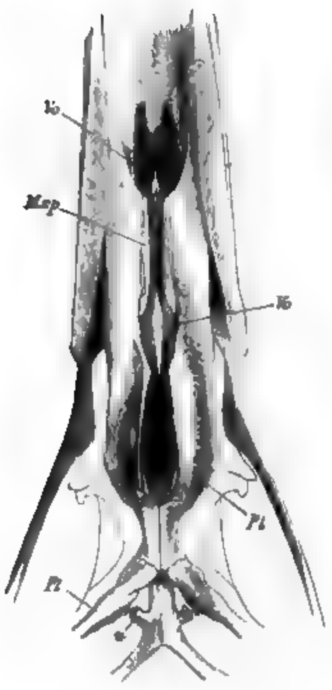


Fig. 12.—*Procellaria gigantea.*

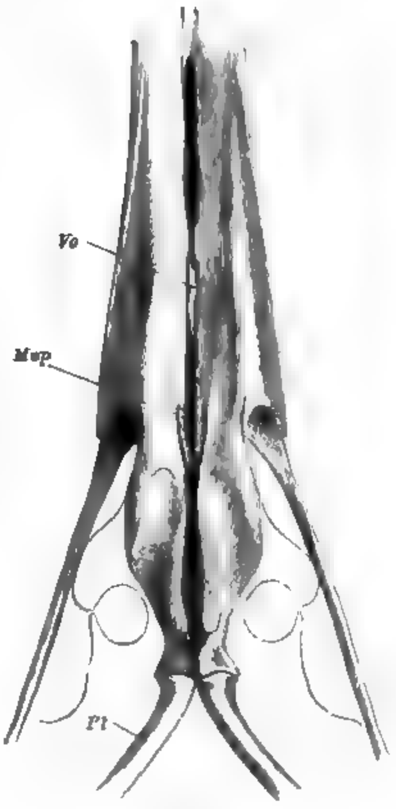


Fig. 13.—*Diomedea exulans.*

Under views of the skulls of *Procellaria gigantea* and *Diomedea exulans*. From specimens in the Museum of the Royal College of Surgeons.
The letters as before.

Didunculus more nearly resembles the ordinary *Columbidæ* in possessing prominent basipterygoid processes; but the palatine bones are thick, their internal laminæ being altogether obsolete. The distal articular facet of the quadrate bone is elongated antero-posteriorly, and nearly resembles the same part in a Parrot. The axis of the fossa of the mandible which receives this facet nearly coincides with that of the ramus of the mandible; while in the other *Columbidæ*

and in *Didus* it is nearly at right angles to the ramus of the mandible. The form of the angle of the mandible in *Didunculus* is quite unlike that observed in the other *Columbidæ* and in *Didus*. In these respects, therefore, *Didunculus* departs further from the ordinary *Columbidæ* than the Dodo does.

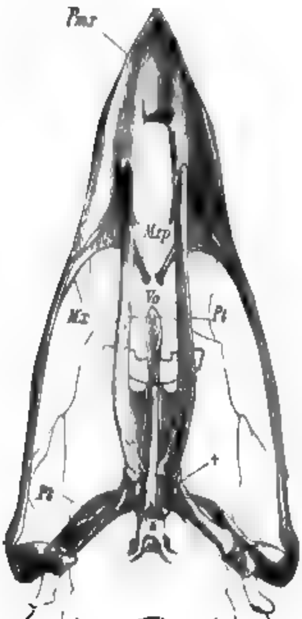


FIG. 14.—Under view of the skull of *Tetrao urogallus*. From a specimen belonging to W. K. Parker, Esq., F.R.S.

The letters as before.

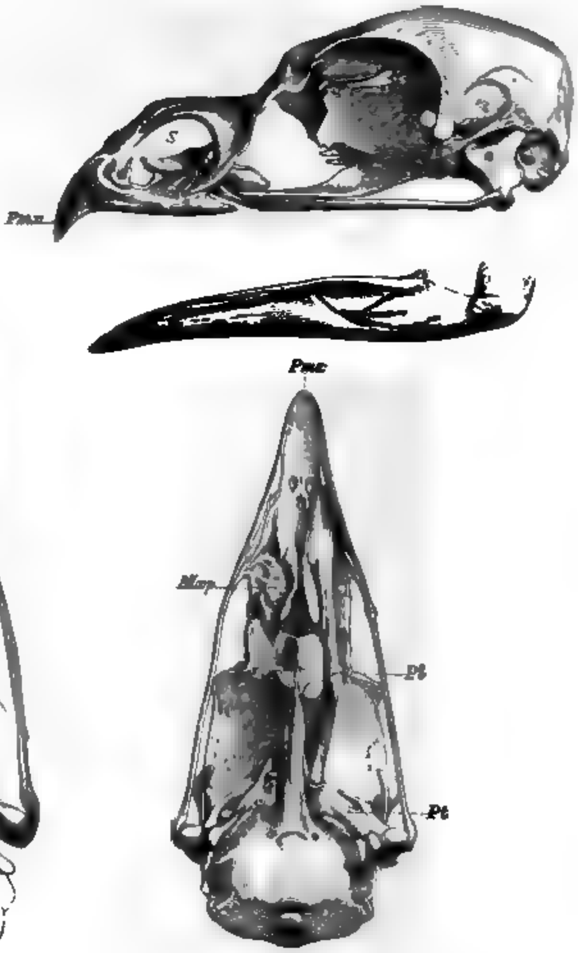


FIG. 15.—Lateral and inferior views of a skull of *Crax globicera*, in the possession of W. K. Parker, Esq., F.R.S.

In the side view *S* denotes the ossified septum. The strong recurved angular process of the mandible is well displayed; the vomer is lost, and is not represented in the inferior view; and the right palatine bone is removed to show the large maxillo-palatine plate of the maxillary (*Mxp*).

I am indebted to Mr. E. Higgins for a skin of that singular bird *Opisthocomus cristatus*, from which I was able to extract an imperfect skull, the inferior face of which is represented in fig. 17. The base of the cranium and the pterygoid bones are wanting.

The underside of the unossified nasal septum supports the slender vomer (*Vo*), which expands and becomes bifurcated anteriorly, in a manner unlike anything which I am acquainted with in other birds.[1] The very slender anterior processes of the palatine bones (the bodies of which are almost entirely wanting in this specimen) are overlapped by the short and broad maxillo-palatines, which

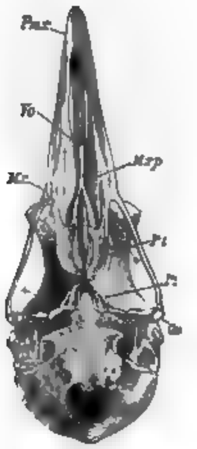


FIG. 16.—Under view of the skull of *Columba palumbus*. The letters as before.

FIG. 17.—*Opisthocomus cristatus*. Under view of an imperfect skull. The letters as before.

remain very distant from the vomer and from one another. The angle of the mandible is slightly produced and bent upwards.

These are all the birds (leaving the *Cracidæ* aside) in which I have noticed the Schizognathous disposition of the palate, which, it must be observed, is characterized not only by the complete distinctness of the maxillo-palatines from one another and from the vomer, but by the slender and usually pointed form of the latter bone.

III. Those Cuvierian Grallæ and Natatores which are not Schizognathous, the Accipitres or Raptores, the Scansores, and, among the Passeres, most of the Fissirostres, all the Syndactyli, and *Upupa* may be termed *Desmognathous*.

In these birds the vomer is often either abortive, or so small that it disappears from the skeleton. When it exists it is always slender and tapers to a point anteriorly.

The maxillo-palatines are united across the middle line, either

[1] In some of the Falcons the vomer has a nearly similar anterior termination, but its connexions are different.

directly or by the intermediation of ossifications in the nasal septum.

The posterior ends of the palatines and the anterior ends of the pterygoids articulate directly with the rostrum, as in the preceding division.

The desmognathous skull appears under its simplest form in *Pala-*

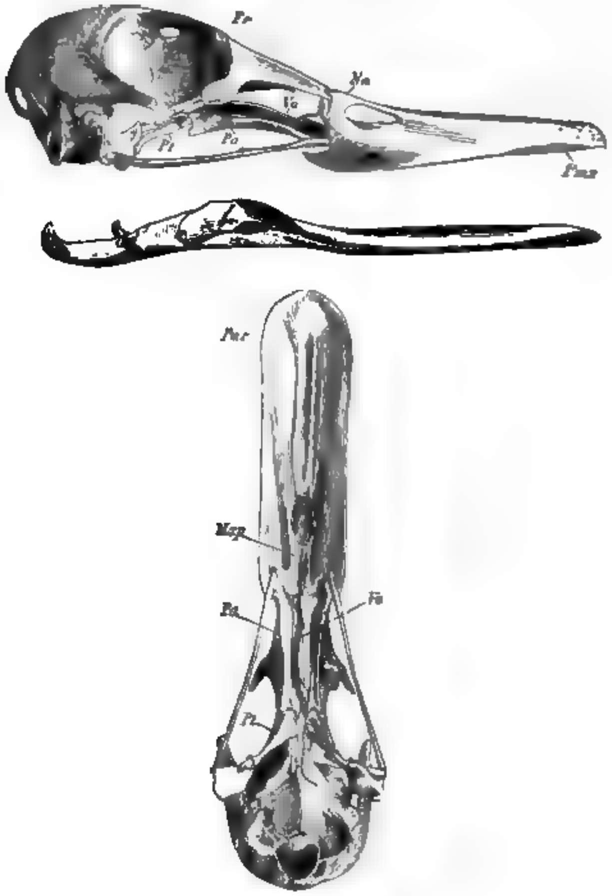


FIG. 18.—*Querquedula crecca.*
Side and inferior views of the skull and mandible. The letters as before.

medea and the Lamellirostres. In these birds each maxillo-palatine is a broad, flat, and thin bony plate, which unites with its fellow in the middle line of the palate. The septum may be more or less ossified. The basipterygoid processes are represented by oval facets, sessile upon the rostrum, and placed so far forward that the surfaces

which articulate with them are situated close to the anterior extremities of the pterygoid bones. In this respect, in the rudimentary condition of the inner lamina of the palatine bone, and in the circumstance that the angle of the mandible is strongly produced and upcurved, these resemble the Gallinaceous birds. They differ from the latter not merely by their "desmognathism," but by the absence of the rounding off of the postero-external angle of the palatine, which is so marked in the Fowls, and by the great proportional length of the region of the skull, which corresponds with the attachment of the lachrymal bone (*Fr* to *Na*, nearly, in fig. 18).

In *Ibis*, *Platalea*, and *Phœnicopterus* the maxillo-palatines not only unite across the vomero-palatine fissures, but, becoming enlarged and spongy, fill the base of the beak. The basipterygoids, rudimentary in *Phœnicopterus*, are absent in *Platalea* and *Ibis*. The angle of the mandible of *Phœnicopterus* has the same prolongation and curvature as in the Lamellirostral birds; in *Platalea* and *Ibis*, while still recurved, it is much shorter and more Plover-like.

The *Ciconiidæ* and *Ardeidæ* have the maxillo-palatines disposed as in the foregoing group. There are no basipterygoids; the angle of the jaw is not prolonged and bent upwards; and the palatine bones are united for a considerable distance behind the posterior nares (fig. 19).

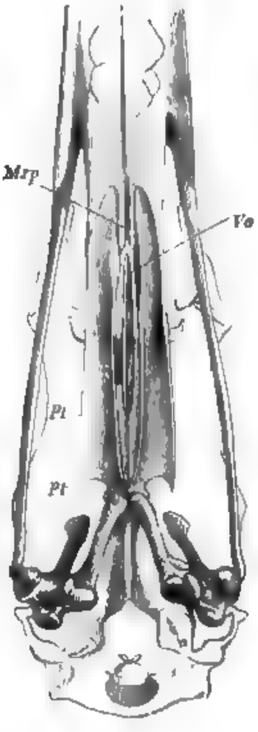


FIG. 19.—Under view of the skull of *Ardea cinerea*. The letters as before.

The same general arrangement is observable in the Cormorants and the Pelicans; but the inner edges of the palatine bones unite for a much greater distance behind the posterior nasal aperture and a median ridge is sent down from the line of junction of the palatines. These birds thus present the most extreme modification of the palatine apparatus which is to be observed in the whole class.

In the *Pelecanidæ* the inferior edge of the ossified interorbital septum rises rapidly forward so as to leave a space at the base of the skull, which is filled by a triangular crest formed by the union of the greatly developed ascending processes of the palatines (fig. 20).

In the Cormorants, on the other hand, the inferior edge of the septum is horizontal, and the crest in question is not developed (fig. 21).

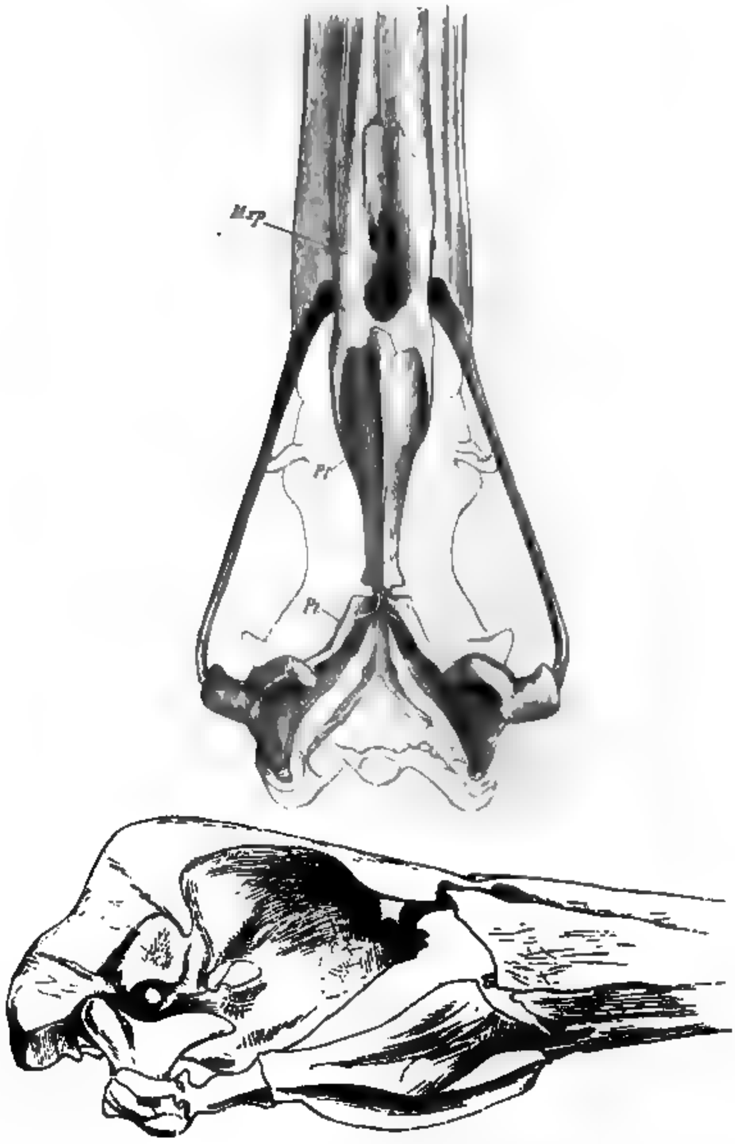


FIG. 20.—Under and side views of the skull of *Pelecanus onocrotalus*; two-thirds the size of nature. The letters as before.

In all the Raptorial birds the nasal septum is ossified for a greater or less extent; and the vertical plate thus formed joins below, by

direct bony union, with the two maxillo-palatines, which are sometimes scroll-shaped, sometimes greatly swollen and spongy.

The vomer, sometimes slender, sometimes pretty broad, always tapers to a point anteriorly.

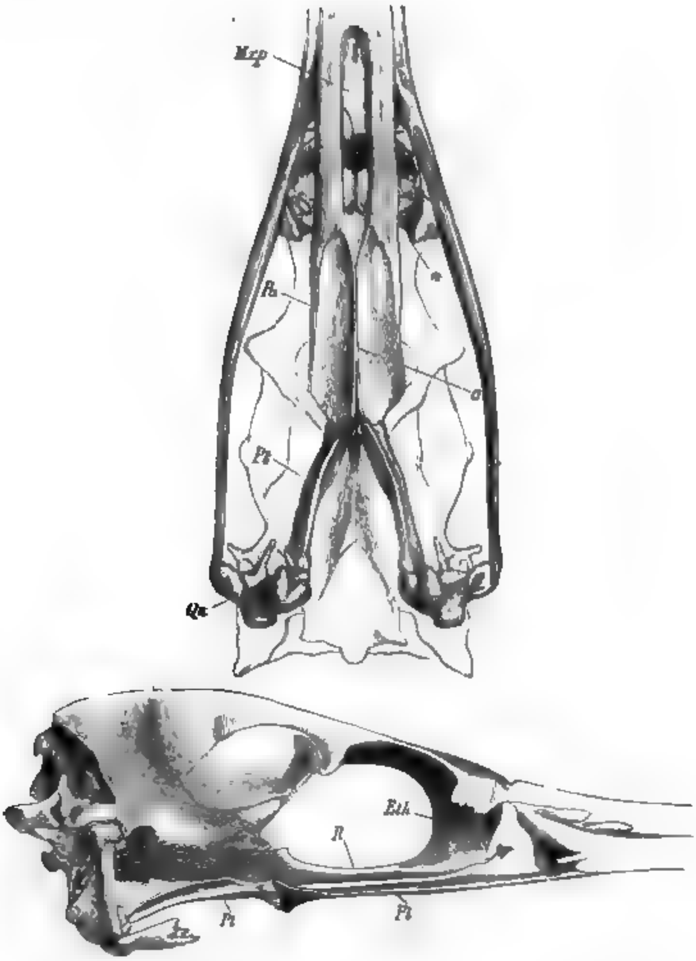


FIG. 21.—Under and side views of the skull of *Phalacrocorax carbo*. The letters as before. *a*. The palatine crest.

The basipterygoids sometimes are and sometimes are not present.

The angle of the mandible is not produced and recurved.

Four modifications of the general type of palatine structure are observable among the Raptorial birds :—

In the genera *Cathartes* and *Sarcorhamphus* the cleft between the

thin and scroll-like maxillo-palatines is very deep and wide, and the ossification of the septum is small in extent, and only forms a sort of bridge over the deep and wide valley between the maxillo-palatines.

The basipterygoid processes are large and articulate with the pterygoids (fig. 22).

In all the Owls the maxillo-palatines are thick and spongy, and encroach upon the intermediate valley, though they never completely unite with one another across it or obliterate its upper part. The basipterygoid processes are always present (fig. 23).

In the Secretary bird (*Gypogeranus*) the maxillo-palatines unite with one another and with the extensively ossified septum, so as to fill up the maxillo-palatine valley. There are well-developed basipterygoid processes.

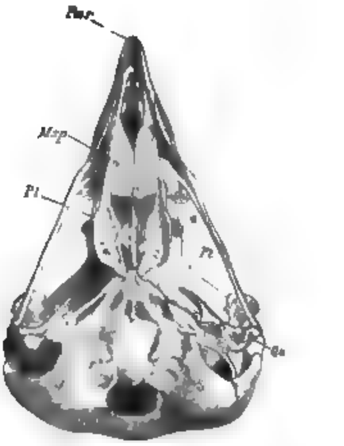


Fig. 23. The base of the skull of *Otus vulgaris*.

The letters have the same signification as before. The inferior and internal margins of the spongy maxillo-palatines almost come into contact; but their inner faces are separated by a wide interval. * The prefrontal processes. The basipterygoid processes are not marked.

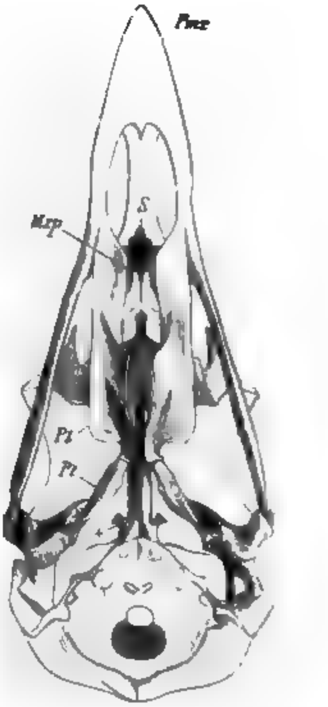


Fig. 22.—Under view of the skull of *Cathartes aura*. From a specimen in the Museum of the Royal College of Surgeons.

The letters as before. + The basipterygoid processes.

In all the other Vultures, Hawks, and Eagles the maxillo-palatines unite with one another and with the largely ossified septum, and there are no basipterygoid processes.

These, therefore, are, so far as their cranial characters go, the

highest of birds of prey, or those which depart most completely from the embryonic condition.

All the Parrots present wonderfully uniform cranial characters. The rostrum is articulated with the frontal bones by a complete hinge-joint. Not only is this the case, but the jugal arches and the palatine bones are moveably articulated by ligamentous joints with the rostrum. There are no basipterygoid processes.

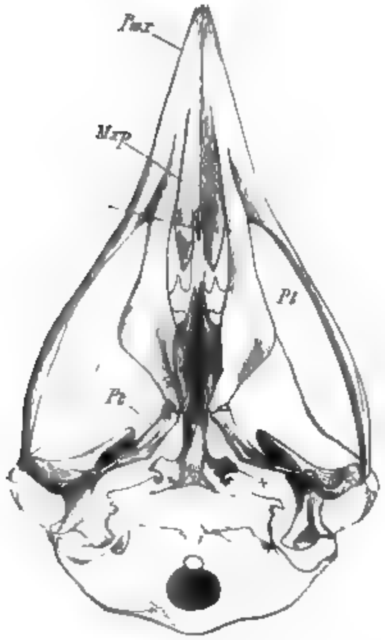


FIG. 24.—Under view of the skull of *Gypogeranus serpentarius*; two-thirds the size of nature. From a specimen in the Museum of the Royal College of Surgeons.

The letters as before. + The basipterygoid processes.

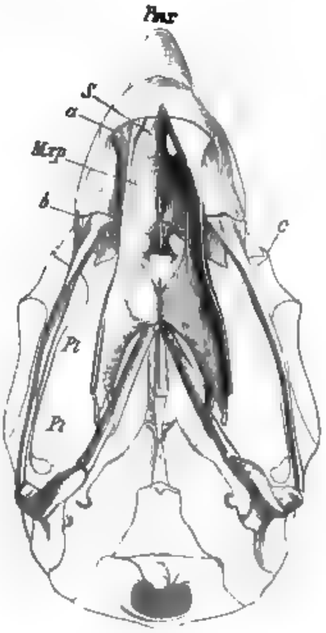


FIG. 25.—Under view of the skull of *Cacatua galerita*.

Pmx, *Mxp*, *Pl*, *Pt*, as before. *S*. The ossified septum narium. *a*. The joint between the palatine and the rostrum. *b*. That between the jugal bone and the rostrum. *c*. The joint between the rostrum and the frontal bones.

The maxillo-palatines are very large and spongy in texture, and unite with one another and with the ossified nasal septum so as to fill up almost the whole base of the beak. Above, however, a nasal passage is left on each side; and, below, the maxillo-palatines stop short, so that, in the dry skull, a passage, leading into the cavity of the rostrum, is left on each side of the septum.

The palatine bones have a highly characteristic figure, being very long, and for three-fourths of their length greatly flattened from side to side, with more or less notched, or festooned, posterior free edges.

Behind the posterior nares each palatine bone sends off a horizontal plate, which unites with its fellow for a considerable distance.

In front of this plate the palatine bones become first rounded and then flattened from above downwards, and broadening out, articulate by transversely elongated heads with fossæ in the posterior margins of the floor of the rostrum.

In the *Musophagidæ* (*Musophaga* and *Schizorhis*) there are no basipterygoid processes. I have not seen the vomer; so that it is probably very small and readily detached. The palatines are considerably elongated, and their posterior external regions rounded off as in the Owls, Pigeons, and *Phasianidæ*. The two spongy maxillo-palatines meet in the middle line; and in these characters, as in the form of the beak, the *Musophagidæ* present a certain resemblance to the Owls.

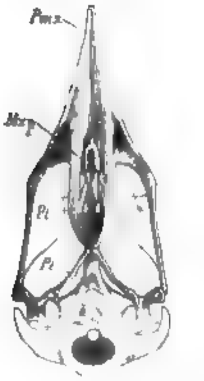


FIG. 26. Under view of the skull of *Cuculus canorus*. From a specimen in the Museum of the Royal College of Surgeons.
The letters as before.

The only *Trogon* skull I have had the opportunity of examining is that of *T. reinwardti*. It possesses basipterygoid processes, in which respect it resembles *Caprimulgus*, and is unlike all the other genera which remain to be mentioned. The palatines have a general resemblance to those of the *Musophagidæ*. The vomer seems to be equally rudimentary; and the maxillo-palatines, though less spongy, unite in the middle line.

Among the *Cuculidæ*, *Cuculus canorus* is devoid of basipterygoids; the palatines are rounded off postero-externally; the internasal septum is well ossified and unites with the maxillo-palatines.

In *Geococcyx* the principle of construction is quite the same; but the postero-external angles of the palatines are distinctly indicated, and the beak is produced into an elongated triangular form. A slight oblique ridge marks off the flat surface of the maxillary process of the palatine from the excavated body of the bone. *Leptosoma* and *Phœnicophaus* present no important differences from *Geococcyx*.

In *Bucco* the general form and arrangement of the parts are as in *Geococcyx*; but the shorter palatines are produced postero-externally into a distinct backwardly directed point; the oblique ridge is much more distinctly defined, and the antero-internal angles of the palatines bend towards one another and nearly meet.

Galbula closely resembles *Bucco*; but the antero-internal angles of the palatines completely meet.

In *Rhamphastos* the only important difference from *Bucco* lies in the circumstance that the antero-internal angles of the palatines not only meet, but are united by bone, while the oblique ridge of the palatines is obsolete. The rostrum moves on the skull by a hinge, almost as freely as in the Parrots.

In *Podargus* the disposition of the parts is essentially the same as in *Bucco* and *Galbula*; but the palatines are exceedingly broad, the oblique ridge in each being very distinct and often having the appearance of a suture. At its external termination the palatine is produced outwards and backwards into a strong process. The inner edges of the palatines unite for a considerable distance; and the form of the beak is completely changed, its great width giving it somewhat the appearance of an ace of spades.

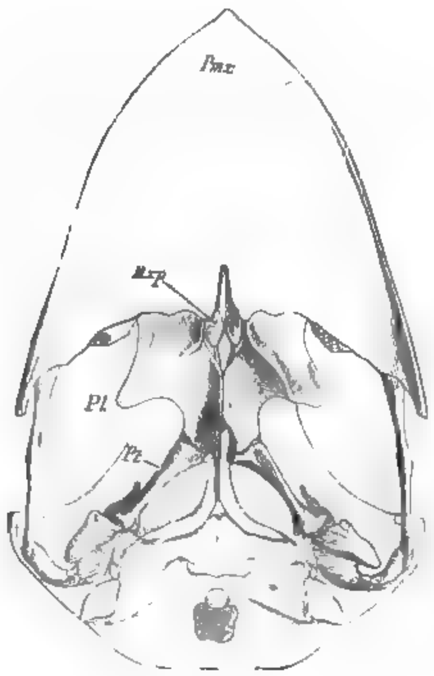


FIG. 27.—Under view of the skull of *Podargus humeralis*. From a specimen in Museum of the Royal College of Surgeons.
The letters as before.

Buceros, leaving aside the mere form of the beak and its frontal enlargement, resembles *Geococcyx* and *Bucco* in the structure of its palate. There are rudimentary basipterygoid processes, but the pterygoids do not articulate with them. The palatines have their postero-external angles completely rounded off and enter into solid union with one another and with the vomer, which has the form of a thin vertical lamella. The internal laminæ of the palatines incline towards one another anteriorly, and meet in front of the posterior nasal aperture, as in *Galbula* and *Rhamphastos*. Anterior to this junction again are situated two considerable apertures (*a*) divided by a median septum; and these lead into the cavity which, for the most part, occupies the interior of the rostrum. I cannot say whether this septum is a prolongation of the vomer, or whether it belongs to the large and spongy maxillo-palatines, which

bound the apertures in question and meet in the middle line with one another and with the vomer. In this genus the external nasal aperture is placed, as is well known, immediately in front of the anterior and upper part of the orbit. It leads into a horizontal passage, with thin, but dense, bony walls, which passes at first almost directly inwards, and then turns forwards at a right angle. The inner wall of the forwardly directed portion of the passage presents a rounded ridge, by which its cavity is imperfectly divided into an upper and a lower passage. The lower opens into the cavity of the rostrum; the upper bends back and opens into a vaulted chamber, to the roof of which a small pyriform "turbinal" is attached by its narrow end. From the inner end of this chamber a passage leads directly downwards and applies itself closely to that of the opposite side. At the level of the lower margins of the external nasal apertures the partition between the two terminates by a sharp, free, curved edge; and in the dry skull, though probably not in the recent state, the nasal chambers of the two sides freely communicate. Lower down they are separated by the vomer, and terminate in the posterior nares.

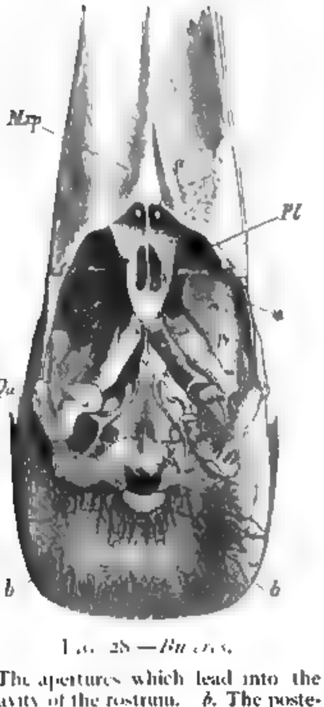


FIG. 28.—*Buceros.*

a. The apertures which lead into the cavity of the rostrum. *b.* The posterior part of the helmet. The other letters as before. [*N.B.* By mistake a * instead of a + is put opposite the rudimentary left basipterygoid process.]

Alcedo and *Dacelo* repeat the structure observed in *Geococcyx*, with minor modifications. For example, the postero-external angles of the palatines are even more produced backwards than in *Bucco* (fig. 29).

This is still more the case in *Upupa*. Here the postero-external angle of the palatine is elongated into a slender, pointed process. The septum is ossified and unites with the maxillo-palatines, which form a transverse bony rafter across the palate.

In *Merops* the long and slender palatines are devoid of any postero-external elongations. The maxillo-palatines are slender and expanded at the end, as in Passerine birds, but they unite in the middle line with one another and with the ossified septum. As the vomer

was absent in the specimen examined, I presume it to have been small and slender.

Coracias has the vomer exceedingly attenuated; and there are no basipterygoid processes. The spongy maxillo-palatines unite and form a thick transverse bar across the palate.

Eurystomus resembles *Coracias*, but has broader palatines.

It will be observed that all the genera of Birds which have been mentioned after the Parrots have their palates constructed upon the same principle as the Cuckoos. With one exception, basipterygoid processes are absent. The maxillo-palatines are united with one another, or with the ossified septum, or with both. The vomer is rudimentary, very small, and readily detached.

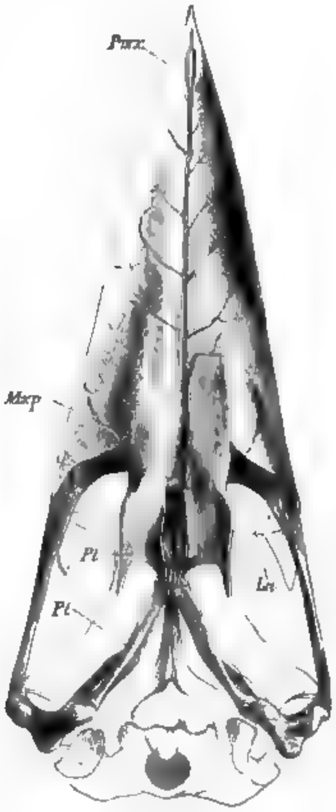


FIG. 29.—*Dacelo gigantea.*
The palatine aspect of the skull. The letters have the same signification as before.

In *Picus viridis* there are no basipterygoid processes. Each palatine bone is flat and obliquely truncated posteriorly, the postero-external angles not being produced. An elongated oval foramen, filled by membrane in the fresh state, occupies the middle third of its inner moiety, and is bounded, in front and internally, by a very slender bar of bone (fig. 30, *c*). This bar is continuous with the palatine by its anterior end. Posteriorly, in some specimens, it appears to be continued directly into the ascending process of the palatine; but in one example I find it to terminate in a pointed end; and the slender bar which corresponds with its apparent continuation in other specimens, is a perfectly distinct ossicle (*Vo*, fig. 30). I am disposed to regard this ossicle and its fellow as the representatives of the vomers, which, if this interpretation be correct, remain exceptionally distinct from one another, but unite with the palatines. The antero-internal angle of the body of the palatine bone sends forwards a slender process, which forms the inner boundary of the posterior half of the palatine foramen.

The maxillo-palatines are broad plates, which appear to terminate by rounded internal edges close to and above the external margins of the palatines. But a tough membrane extends inwards from the free edge of each maxillo-palatine and meets with a delicate longitudinal ossification of the septum (*a*, fig. 30). Opposite the anterior termination of the external nasal aperture this ossification is connected with a transverse bar of bone, which stretches from one premaxilla to the other, and shuts off the cavity enclosed by the premaxillæ from the nasal chambers. The latter are greatly complicated by the development of twisted "turbinal" plates in connexion with the nasal and premaxillary bones and the ethmoid.

FIG. 30.—The palate of *Picus viridis*.
a The ossified septum. *b*. The transverse bar of bone connected with it. *Vo*. The ossicles which probably represent the vomers. *Pmx*, *Mxp*, *Pl*, *, as before.

A prolonged and careful study of fresh specimens will be necessary before the arrangement of the parts in *Picus* can be thoroughly understood. In the meanwhile it is clear that, in this genus, the palate differs very widely from that observed in any of the preceding "cuculiform" genera.

In *Picus major* the palatine bones have the same structure and arrangement as in *P. viridis*, except that their posterior ends are transversely truncated and the postero-external angles are even a little produced. The maxillo-palatines are much smaller than in the preceding species, and their inner rounded edges do not nearly reach the level of the outer edges of the palatines.

Picus canus resembles the preceding; but the postero-external angles of the palatines are rather better marked, and the maxillo-palatines a little larger.

Picus medius presents no difference of importance, except that the inner laminæ of the palatines, obsolete in the other genera, are a little better marked, especially behind.

In *Picus minor* distinct maxillo-palatines can hardly be said to be present, the maxillary presenting only a slight dilatation at the point where they should exist. Minute points of bone projecting from the inner edges of the palatines alone indicate the position of the process (*c*) in *Picus viridis* and of the prolongation of the antero-internal angle of the body of the palatine. The "oval foramen" consequently is indicated only by a slight excavation of the inner margin of the palatine.

This species of *Picus* prepares one in some degree for the structure observed in *Yunx* (fig. 31). Here the ascending processes of the palatine bones are produced forwards into long and slender processes, slightly swollen at their anterior free ends, which may represent anchylosed vomers. The inner edges of the short and broad bodies of the palatine bones approach so nearly as only to leave a cleft for the posterior nares. The antero-internal angles are acute, but not greatly prolonged. The anterior processes of the palatines are very slender, and the inner edge of each is angulated near its anterior termination. This angulation may represent the process *c* (fig. 30) in *Picus viridis*. The maxillo-palatines are represented by mere ridges on the inner side of the maxillæ, bounding a fossa. No ossification of the septum remains in any of the skulls of *Yunx* I have examined.

FIG. 31.—View of the palate of *Yunx torquilla* (× 2). The letters as before.

I have discussed *Picus* and *Yunx*, in this place, because of the general agreement among ornithologists that *Picus* and its allies are closely related to the Cuckoos and other "Scansores." But it is clear that nothing can be more different than the cranial structure of the *Picidæ* and that of any of the other "*Scansores*;" and, indeed, judging from the dry skull alone, the Woodpeckers are not even desmognathous. But, as I have already hinted, a question of this systematic importance cannot be finally settled without the careful investigation of fresh specimens.

IV. The remaining Carinatæ have a palatine structure which is in some respects intermediate between that of the Schizognathous and that of the Desmognathous groups, while in others it is peculiar.

This structure, which I term Ægithognathous, is well exemplified by any of the typical Passerine Birds as, for example, a Raven (fig. 32).

The vomer is a broad bone, abruptly truncated in front, and deeply cleft behind, embracing the rostrum of the sphenoid between its forks. The palatines have produced postero-external angles. The maxillo-palatines are slender at their origin, and extend inwards and backwards obliquely over the palatines, ending beneath the vomer in expanded extremities, which do not become united by bone, either with one another or with the vomer. The anterior part of the nasal

septum (in front of the vomer) is frequently ossified in Ægithognathous birds, and the interval between it and the premaxilla filled up with spongy bone; but no union takes place between this ossification and the vomer.

This structure (which was first accurately described and its systematic importance pointed out by Nitzsch)[1] is substantially repeated in the great majority of Passerine birds, though with minor modifications, which I suspect will turn out to be characteristic of the natural subdivisions of this great group. At present I can only mention two or three of these.

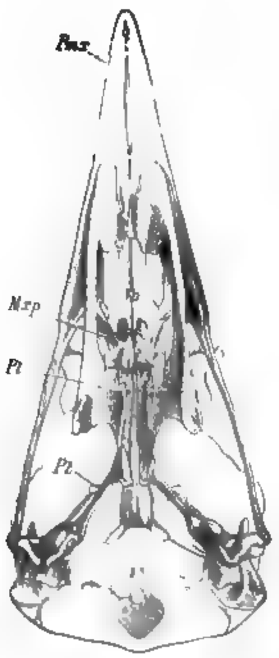


FIG. 32.—Under view of the skull of *Corvus corax*. The letters as before.

Menura differs from all the rest in possessing no ossified maxillo-palatines whatever. The vomer, though broad and deeply cleft posteriorly, is more rounded off than abruptly truncated at its anterior end.

In *Tyrannus*, in *Cephalopterus*, in *Coracina* (according to Burmeister), and perhaps in others of the American Passerines without a singing-apparatus, the bases of the maxillo-palatines are broader than their free ends, and there is no narrow stem.

Chasmorhynchus nudicollis, however, has maxillo-palatines of the ordinary character; and in *Pteroptochus megapodius* they are long, slender, and recurved.

In *Gymnorhina* the septo-premaxillary ossification and the maxillo-palatines are confluent, though the latter and the vomer remain quite distinct from one another.

In these and the majority of typical Passerine birds the palatine bones are broad and comparatively flat posteriorly; but in the Finches the outer lamina of each palatine acquires a great downward development, and becomes a vertical plate, the free posterior edge of which is more or less notched. The anterior process of the palatine at the same time broadens out, and becomes connected by a truncated edge with the rostrum, which attains great height and breadth, and is sometimes hooked anteriorly.

[1] See the article "Passerinæ" in Ersch and Grüber's "Encyclopædie," 1840, and Nitzsch, "Ueber die Familie der Passerinen," in the "Zeitschrift für die gesammten Naturwissenschaften," 1862.

The palate thus acquires a singular superficial resemblance to that of a Parrot, from which it differs, however, in the separation of the palatines in the middle line, in the form and size of the vomer, and in the slender, recurved, and separate maxillo-palatines (fig. 33).

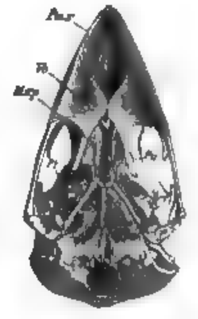


FIG. 33.—Under view of the skull of *Coccothraustes vulgaris*. The letters as before.

Pipra erythrocephala and *Tanagra cyanoptera* are similar to the Finches in the form of the palatines.

The Swallows completely agree with the other Passerine birds in the general form and arrangement of the bones which enter into the composition of their palates.

And the Swifts essentially resemble the Swallows, though the form and proportions of the palatine bones are somewhat different (fig. 34).

The skull of *Caprimulgus*, though it retains the general features of the Passerine cranium, departs from the typical Passerine structure still further than the Swifts, the body of the palatines having become exceedingly broad and flattened out, while the vomer is longer and narrower than in the Swifts or the typical Passerine birds. The expanded inner ends of the slender and characteristically Passerine maxillo-palatines are quite distinct from the vomer and from one another.

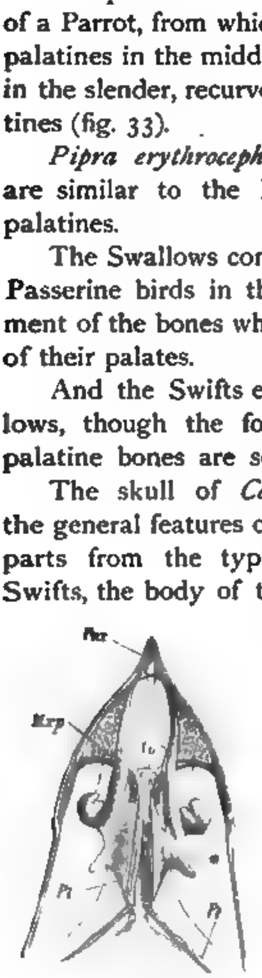


FIG. 34.—The palate of *Cypselus apus* (× 2). The anterior excavated end of the vomer has a crescentic shape, its angles terminating in free horns above the palatine bones, by which they are concealed in the figure. The inferior ends of the prefrontal processes (*) have a very peculiar form.

Caprimulgus further presents a remarkable contrast to the Swifts and all the true Passeres in having well-developed basipterygoid processes. These are absent in *Ægotheles novæ-hollandiæ*, the palate of which is intermediate between that of the Goatsuckers and that of the Swifts.

Nyctibius closely resembles *Caprimulgus*, even to possessing the very peculiar division of each ramus of the mandible into two portions, the one of which is moveable upon the other, pointed out in the latter genus by Nitzsch. But the slender anterior processes of the palatines are closely approximated in the middle line, instead of remaining widely separated as in *Caprimulgus* and *Trochilus*; and the maxillo-palatines are closely adherent

to them and to the vomer, though a true anchylosis does not appear to have taken place.

Trochilus has the true Passerine vomer, with its broad and truncated anterior, and deeply cleft posterior end. I have not yet been able to obtain a perfectly satisfactory view of the structure and arrangement of the palatine bones in the Humming Birds.

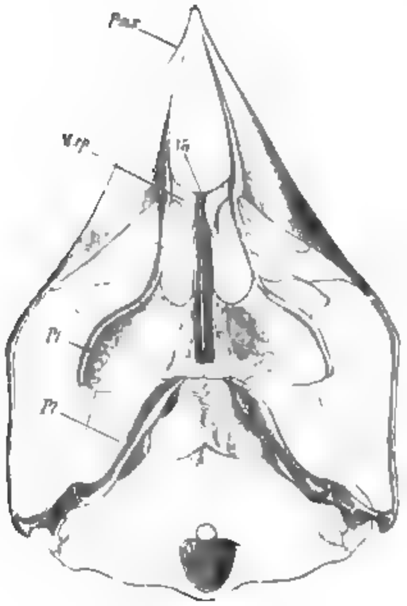


Fig. 35.—Under view of the skull of *Caprimulgus europæus* (× 2). The letters as before.

That the birds of which I have spoken under the four heads

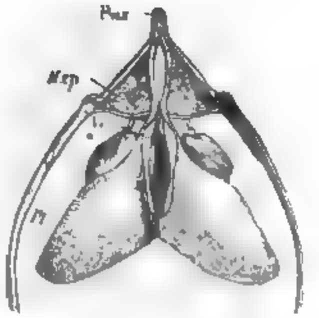


Fig. 36.—*Nyctibius Jamaicensis.* View of the palate without the pterygoid bones. The letters as before.

of *Dromæognathous*, *Schizognathous*, *Desmognathous*, and *Ægithognathous* really possess the various arrangements of the palatine and adjacent bones which I have described, is a matter of observation which readily admits of confirmation or the reverse. It is another and very important question whether these cranial characters may safely be taken as indications of natural affinities; and I now propose to make a few remarks on that point.

It will not, I think, be disputed by any ornithologist that the *Schizognathous* birds constitute a very natural assemblage. Taking the Plovers and their allies as the most central group of these birds, we may pass, without a break of more than family importance, along several distinct series, or gradations of ornithic forms.

Thus, along one line, the Bustards are intermediate between the Plovers and the Cranes; while *Psophia* and *Rhinochetus* lead from the Cranes to the Rails.

Following another line, *Hemipodius* stands between the Plovers and the Fowls; while *Syrrhaptes* inclines, on the one hand, to the typical Gallinaceous birds, and on the other to the *Columbidæ*.

A third series is commenced by the Gulls. The osteological resemblances between a Plover, a Gull, an Auk, and a Diver are so close that it is utterly out of the question to regard these Birds as members of different orders. But the Gulls grade insensibly into the *Procellariidæ*; and, though the *Apterodytidæ* appear to be separated by a broad gap from the *Alcidæ*, *Alca impennis*, in the form of its humerus, in the mode of articulation of the radius and ulna with the humerus, in the proportions and structure of the tarsometatarsal bone, shows itself to be an almost intermediate form.

I am acquainted with only two birds, *Dicholophus* and *Crax globicera*, the structure of the skull of which would lead me to regard them as transitional between the Schizognathous and the Desmognathous sections, or, at any rate, as approaching the latter division.

Nitzsch and Burmeister have assigned to *Dicholophus* a position near the Cranes and the Rails, and, no doubt, justly on the whole, though I venture to think that they have underrated the points of resemblance to the birds of prey, and especially to *Gypogeranus*. In the skull of *Dicholophus* the internasal septum is ossified to a very slight extent, and the maxillo-palatine processes may meet in the middle line, in both of which respects it approaches the birds of prey. But the ossified part of the nasal septum does not unite below with the maxillo-palatines; and in this respect *Dicholophus* is unlike the Raptorial birds.[1]

Crax globicera, on the other hand, while it retains the characteristically Gallinaceous basipterygoid articular surfaces, palatine bones, angle of the mandible, and other peculiarities, has a partially ossified nasal septum, which divides below and unites with the maxillo-palatines, just as in the Raptorial birds.

The *Cuculidæ* and *Alcedinidæ* occupy nearly the same middle place in the Desmognathous series that the Plovers have among the Schizognathous families. The *Musophagidæ* bring them into relation with the Raptorial birds, the *Rhamphastidæ* with the Parrots, the *Podargidæ* with the *Cancroma*,[2] and so with the Herons and Storks. But these last are clearly affined, on the one hand, with the Cor-

[1] Mr. Parker is inclined to lay a still greater stress than I have done upon the many Raptorial characters of *Dicholophus*.

[2] A hazardous suggestion, but one the temerity of which will perhaps appear less after a careful comparison of the skulls of these two birds.

morants and Pelicans, on the other with the Flamingos, and through the latter with the Lamellirostres.

It is unnecessary to enumerate the arguments by which the close affinity of the proper Passerine birds (which make up the great bulk of the Ægithognathous section) may be demonstrated, as the eminently natural character of this group is admitted by every one.

In their cranial characters, the Swifts are far more closely allied with the Swallows than with any of the Desmognathous birds, the Swift presenting but a very slight modification of the true Passerine type exhibited by the Swallow. No distinction can be based upon the proportions of the regions of the fore limb; since in all the Swallows which I have examined[1] the manus and the antebrachium respectively, greatly exceed the humerus in length, though the excess is not so great as in *Cypselus.*

The modification commenced in the Swift is greatly exaggerated in *Ægotheles* and *Caprimulgus*; while we have almost a transition to the Desmognathous structure in *Nyctibius.*

But if palatine characters have the taxonomic value which the facts just enumerated appear to indicate, it follows that the *Dromæognathous* structure, so different from what is to be seen in any other Carinate birds, has as much value as the rest, notwithstanding the small actual extent of the group in which it obtains.

It thus appears that the Dromæognathous, Schizognathous, Desmognathous, and Ægithognathous arrangements of the maxillary and palatine bones, respectively, characterise divisions of the Carinatæ, all the members of which are mutually affined in other respects. And I propose to regard these divisions as suborders, and to name them DROMÆOGNATHÆ, SCHIZOGNATHÆ, DESMOGNATHÆ, and ÆGITHOGNATHÆ.[2]

The suborder DROMÆOGNATHÆ, containing only one family, the *Tinamidæ*, admits of no subdivision into groups of larger extent than families; but the other three suborders are very extensive, and, I think, may be so subdivided in an approximately satisfactory manner, though any definition of these subdivisions which can be proposed at present must be regarded as provisional and open to extensive revision as our knowledge of the details of ornithic organization widens.

[1] *Hirundo pacifica, H. riparia, H. rustica, H. urbica.*

[2] *Dromæus*, the generic name for the cassowaries; σχίζω, to cleave; δεσμὸς, a bond; Αἴγιθος, a sparrow.

The SCHIZOGNATHÆ. In addition to their cranial characters, the birds composing this suborder often want intrinsic muscles in the lower larynx, and never possess more than one pair of them.

With the exception of *Podiceps*, all the genera which have been examined have two carotid arteries.

Six groups of allied families are distinguishable in this suborder. These may be termed the CHARADRIOMORPHÆ, the GERANOMORPHÆ, the CECOMORPHÆ, the SPHENISCOMORPHÆ, the ALECTOROMORPHÆ, and the PERISTEROMORPHÆ.[1]

1. The CHARADRIOMORPHÆ.

The rostrum is always elongated and comparatively slender. The base of the skull possesses narrow and prominent basipterygoid processes. The maxillo-palatines are concavo-convex and lamellar, never swollen or spongy. The angle of the mandible is produced into a slender and abruptly recurved process.

The sternum is sometimes singly, but, more usually, doubly notched.

The hallux, always small, is sometimes absent.

The phalanges of the anterior toes diminish in length from the basal to the penultimate.

The pterylosis of this group, which nearly corresponds with the pressirostral and longirostral Grallæ of Cuvier and with the *Limicolæ* and *Scolopacinæ* of Nitzsch, has been carefully described by the latter writer, who remarks that, "next to the *Passerinæ* and *Gallinaceæ*, this group appears to present the smallest pterylographic differences,"[2] and that in the form of the tracts it closely approaches *Psophia* and *Grus*.

The feathers always cease above the suffrago, though sometimes the bare area is very small; and the webs between the front toes are large only in *Recurvirostra*.

2. The GERANOMORPHÆ.

The rostrum is relatively stronger than in the preceding group, and may even be short and arched.

Basipterygoid processes are absent (ex. *Grus antigone*).

The maxillo-palatines are concavo-convex and lamellar.

[1] Χαραδριὸς, a sea-lark, or plover; Γέρανος, a crane; Κ.ξ, a gull; *Spheniscus*, a genus of penguins; Ἀλέκτωρ, a cock; Περιστερὰ, a dove; μορφὴ, form.

[2] See Nitzsch, "Pterylography" (Ray Society's Edition), p. 134.

The angle of the mandible is truncated.

In the typical groups the sternum is comparatively narrow and elongated, and may be deeply notched or entire.

The feet vary greatly, but the toes are never completely or even extensively webbed; and the ratio of the length of the phalanges of the toes is as in the preceding division.

A greater or less space above the suffrago is devoid of feathers: but there appears to be nothing characteristic about the pterylosis of this group.

I consider the Cranes and the Rails (between which *Psophia* and *Rhinochetus* are intermediate) the typical forms of this group.

Otis connects it with the Charadriomorphæ, and *Dicholophus* with the birds of prey; but it is a question whether these two genera may be better included in this group, or made types of separate groups.

3. The CECOMORPHÆ.

The rostrum varies greatly in shape; but is very generally compressed from side to side, and hooked at the extremity.

Procellaria gigantea alone has presented basipterygoid processes.

The maxillo-palatines are usually lamellar and concavo-convex as in the preceding groups; but in the *Procellariidæ* they become tumid and spongy, and may enlarge so much as to leave a mere cleft in the place of each vomero-palatine space.

The angle of the mandible is not recurved.

The sternum varies extensively.

The hallux is weak, or absent, and (with the exception of the Grebes) the anterior toes are completely, or very largely, webbed. The ratio of the phalanges is as in the preceding groups.

This group contains the *Laridæ* (*Longipennes*, Nitzsch), the *Procellariidæ*, the *Colymbidæ*, and the *Alcidæ*. Nitzsch (*l. c.*) remarks that the pterylosis of the first-named family "approaches very closely to that of the Scolopacinæ, and can hardly be distinguished therefrom by any character;" and the same may be said of the osteological and other peculiarities of the *Laridæ*, which come very near the Charadriomorphæ. The *Alcidæ*, on the other hand, in their pterylosis and other characters approach the Penguins—especially, as has been noted above, through *Alca impennis*. The *Colymbidæ* appear to be closely connected on the one hand with the Gulls, and on the other, more remotely, but still really, with the Rails.

The *Procellariidæ* are aberrant forms inclining towards the Cormorants and Pelicans among the Desmognathæ.

4. The SPHENISCOMORPHÆ.

The beak is straight and compressed, the rostrum being, at most, slightly hooked at the tip.

There are no basipterygoid processes, and the pterygoids are flattened from above downwards.

The maxillo-palatines are concavo-convex and lamellar.

The sternum is greatly elongated.

The shaft of the humerus is flattened from side to side, and its distal end presents an obliquely truncated surface, with which the similarly compressed radius and ulna articulate—the former altogether with the fore part, the latter with the hinder part of the humeral articular surface.

There is no free pollex.

The pelvic bones are less firmly connected with the sacrum than in any other birds.

The short tarso-metatarsus is perforated by two very large clefts which lie between the middle and the lateral metatarsals. The small hallux is directed inwards or forwards. The ratio of the phalanges is as in the preceding groups.

The anterior toes are completely webbed.

This group answers to the Squamipennes of many authors, and contains the single family *Apterodytidæ*, comprising the genera *Eudyptes*, *Spheniscus*, and *Apterodytes*.

Nitzsch has pointed out that these birds have no remiges distinct from the other feathers, which are distributed evenly over the whole body, and, though small and scale-like, are provided with an after-shaft.

5. The ALECTOROMORPHÆ.

The rostrum may be slender and depressed, or high and arched. Oval, flattened basipterygoid facets, sessile upon the basisphenoidal rostrum and articulating with corresponding surfaces upon the pterygoids are always present. The maxillo-palatines are always lamellar, but vary greatly in size, being sometimes very small.

The palatine bones are relatively long and narrow, with obsolete internal laminæ, and rounded-off postero-external angles.

The angle of the mandible is produced into a strong upcurved process.

The sternum has either one or more, generally two, very deep posterior notches on each side; when there are two, the external lateral processes thus marked out are much shorter than the internal.

The feet vary considerably in the relative size and in the position of the hallux, and in the development of spurs. They are never completely, or even largely webbed. The ratio of the phalanges of the front toes is as in the preceding groups.

According to Nitzsch the feathers have aftershafts, and the pterylosis is remarkably uniform in all the genera except the *Pteroclidæ*, a family which, in this and some other respects, but not in cranial characters, approaches the Pigeons.

Except in *Pterocles*, the oil-gland is surmounted by a circlet of feathers.

The inferior larynx is always devoid of intrinsic muscles.

Excluding the Pigeons and the *Tinamidæ*, this group corresponds with the Gallinæ of authors, and contains the families *Turnicidæ*, *Phasianidæ*, *Pteroclidæ*, *Megapodidæ*, and *Cracidæ*.

The *Turnicidæ* approach the Charadriomorphæ, the *Pteroclidæ* the Peristeromorphæ; while the *Cracidæ* have relations with the birds of prey on the one hand, and with *Palamedea* and the other Chenomorphæ on the other.

6. The PERISTEROMORPHÆ.

The rostrum is swollen at the tip, and provided at the base with a tumid membranous space, in which the nostrils open.

The skull is provided with narrow, but prominent, basipterygoid facets.

The maxillo-palatines are elongated and spongy.

The angle of the mandible is not produced and recurved.

The sternum has two posterior notches, the inner pair of which may be converted into foramina. The external lateral processes thus formed are, as in the Alectoromorphæ, much shorter than the internal lateral processes.

The hallux is on a level with the rest of the toes, and its metatarsal is peculiarly twisted. The anterior toes are not at all webbed. The ratio of the phalanges is as in the preceding groups.

The feathers have no aftershaft (? *Didus*), and the oil-gland is devoid of a circlet of feathers.

The inferior larynx is provided with a single pair of intrinsic muscles (? *Didus*).

The relations of the Peristeromorphæ with the Alectoromorphæ are very close. On the other side they seem to be allied with the Owls and the Vultures.

I have not been able to examine for myself, more than an incomplete skull and the feet of *Opisthocomus.* The phalanges of the anterior toes (leaving the ungual phalanges out of consideration) are nearly equal in length. The tarso-metatarse is similar to that of the Alectoromorphæ. But the extraordinary sternum, furcula, and the many other peculiarities of this bird described by L'Herminier, Deville, and Gervaise lead me to think that it must be placed in a special subdivision of the Schizognathæ.

The DESMOGNATHÆ, like the Schizognathæ, may be without intrinsic muscles of the lower larynx, or they may possess only one pair, or they may have three pairs; but the lower larynx is never constructed on the plan of that of the song-birds.

The carotids may be double or single.

Not fewer than seven groups of families appear to me to be clearly distinguishable in this suborder, viz. the CHENOMORPHÆ, the AMPHIMORPHÆ, the PELARGOMORPHÆ, the DYSPOROMORPHÆ, the AETOMORPHÆ, the PSITTACOMORPHÆ, and the COCCYGOMORPHÆ. In addition to these undoubted Desmognathæ I shall at the end of this series consider the Woodpeckers under the name of CELEOMORPHÆ.[1]

1. The CHENOMORPHÆ.

The lachrymal region of the skull is remarkably long.

The basisphenoidal rostrum has oval, sessile, basipterygoid facets, like those of the Alectoromorphæ.

The flat and lamellar maxillo-palatines unite and form a bridge across the palate.

The angle of the mandible is greatly produced and recurved.

The sternum has a single pair of notches at its truncated posterior margin.

The feet generally have a short hallux, and the anterior toes are completely webbed; but *Palamedea* and *Anseranas* are remarkable exceptions to this rule. The phalanges of the anterior toes decrease in length from the basal to the penultimate.

The oil-gland is surmounted by a circlet of feathers, and the larynx has no intrinsic muscles (? *Palamedea*).

[1] Χὴν, a goose; ἀμφὶ, on both sides; Πελαργὸς, a stork: *Dysporus*, a generic name applied to the gannets by Illiger; 'Αετὸς, an eagle; Ψίττακος, a parrot; Κόκκυξ, a cuckoo; Κέλεος, a woodpecker.

2. The AMPHIMORPHÆ.

The genus *Phœnicopterus* is so completely intermediate between the Anserine birds on the one side, and the Storks and Herons on the other, that it can be ranged with neither of these groups, but must stand as the type of a division by itself.

Thus the skull has the long lachrymo-nasal region, the basipterygoid facets, the prolonged and recurved angle of the mandibles, the laminated horny sheath of the Chenomorphæ; but the maxillo-palatines are spongy, and the general structure of the rostrum is quite similar to that found in the Stalks and Herons.

The lower end of the crus is bare; but the feet are fully webbed, and the pterylosis is said by Nitzsch to be "completely Stork-like."

3. The PELARGOMORPHÆ.

There are no basipterygoid processes, and the palatines usually unite for a greater or less distance behind the posterior nares; but they send down no vertical plate from their junction.

The maxillo-palatines are large and spongy.

The angle of the mandible is truncated (except in *Platalea* and *Ibis*).

The sternum is broad, and may have two or four posterior notches.

The hallux varies in its proportions, but is not turned forwards or inwards, or united by a web with the other toes, the web between which is always incomplete. The ratio of the phalanges is as in the preceding groups.

The oil-gland is surmounted by a circlet.

The disposition of the carotids and the characters of the larynx vary.

I associate in this division the *Herodiæ*, *Pelargi*, and *Hemiglottides* of Nitzsch. The last group, including the genera *Ibis* and *Platalea*, differs from the rest in having a produced and recurved mandibular angle, and in some other respects approaches *Phœnicopterus*. The typical forms incline rather to the succeeding group.

4. The DYSPOROMORPHÆ.

The rostrum is long and pointed and more or less curved, and the external nasal apertures are very small. There are no basipterygoid processes. The palate-bones unite for a considerable distance be-

ıind the posterior nares, and send down a vertical crest from their unction.

The maxillo-palatines are large and spongy.

The angle of the mandible is truncated.

The sternum is broad, and its truncated posterior edge is either :ntire or has a shallow excavation on each side of the middle line.

The hallux is turned forwards or inwards, and is united by a web vith the completely webbed anterior toes. The ratio of the phaanges is as in the preceding genera.

The oil-gland is surmounted by a circlet of feathers.

This group answers to the "Steganopodes" of Illiger; and since he appearance of the admirable memoir of Brandt, "Zur Ostéologie ler Vögel," in 1840, no doubt can have been entertained as to its exremely natural characters. The genera composing it are sharply livided by the structure of the skull, described above, into two groups —the one containing the Pelicans, the other the remaining genera.

5. The AETOMORPHÆ.

The rostrum is more or less arched and hooked at the tip, and at ts base there is a cere in which the nostrils are pierced. Basipterygoid processes may be present or absent. The maxillo-palatine proesses may be concavo-convex lamellæ, or may be spongy and fill up he base of the rostrum, but they are always united with an ossificaion of the septum.

The breadth of the articular surface at the distal end of the quadrate bone is greater than its length, the outer condyle extending ıbout as far downwards as the inner.

The angle of the mandible is never recurved.

The sternum is broad, and has a strong carina. Its posterior edge nay be entire, or may have one or two notches on each side.

The pelvis and the tarso-metatarsus vary greatly. The feet always ›ossess a hallux; the fourth toe is never permanently turned backvards, and the anterior toes are never completely or even largely vebbed. In other respects they vary.

There are always two carotids.

The inferior larynx may be wanting, and when developed has not nore than one pair of intrinsic muscles.

The circlet of feathers may be present or absent upon the oil-;land; and the contour feathers have, or have not, an aftershaft.

The division of the Aetomorphæ is equivalent to the "Raptores" f Cuvier—an eminently natural assemblage, and yet one the members

of which, as the preceding enumeration of their characters shows, vary in most important particulars.

They appear to me to fall naturally into four well-defined primary groups—the *Strigidæ*, the *Cathartidæ*, the *Gypaetidæ*, and the *Gypogeranidæ*. But this arrangement is so different from that ordinarily adopted, that I shall proceed to justify it by enumerating the principal circumstances in which the members of the several divisions agree with one another and differ from the rest.

In the *Strigidæ*, or Owls, the feathers want the aftershaft, and the oil-gland is not surmounted by a circlet of feathers. The hallux is more than half as long as the fourth toe, and on a level with the other toes. The claws are long, curved, and acute, and the fourth toe is reversible.

The first three phalanges of this toe are subequal and very short; all three together are not so long as the penultimate phalanx.

The basal phalanx of the third toe is not longer than the second, and is far shorter than the penultimate.

The tarso-metatarsus is extremely flattened, with strong lateral ridges, the inner edge being particularly thin; and, usually, there is an osseous loop for the extensor tendons on its front face.

The posterior face of the proximal end of the tarso-metatarsus presents two ridges (of which the inner is very much stronger and more prominent than the almost obsolete outer) separated by a deep and wide groove.

The skull is broad, and the bones of the brain-case have a spongy diploë. Basipterygoid processes are always present, and the tumid and spongy maxillo-palatines are separated by an interval, which may be wide throughout, or reduced to a cleft below.

The peculiarly spongy lachrymal remains distinct for a long time, if not throughout life, from the frontal bones and the prefrontal processes.

The external nares may be long, but are never pervious, the septum being well ossified.

The sternum is commonly four-notched, and has a manubrial process.

The proximal ends of the clavicles are comparatively little expanded or recurved, and become very slender towards their symphysis. The clavicular process of the coracoid fits into an excavation on the outer surface of the clavicle. The scapular process of the coracoid is prolonged forwards to meet the clavicle. The lower larynx possesses one pair of intrinsic muscles.

The *Cathartidæ* comprise the Vultures of the New World (*Cathartes* and *Sarcoramphus*).[1] The feathers have no aftershaft, and the oil-gland wants the circlet of feathers. The phalanges of the hallux, taken together, are about half as long as those of the outer toe, and the articular surface of its short metatarsal lies above the level of the articular faces of the other metatarsals; the claws are blunt and comparatively straight, and the fourth toe is not reversible.

The second and third phalanges of the fourth toe, taken together, are as long as, or longer than, the basal phalanx.

The basal-phalanx of the third toe is longer than either the second or the penultimate, the two latter being subequal.

The tarso-metatarsus is thick, and its inner edge rounded and not much thinner than the other.

The posterior face of the proximal end of the bone presents a broad and prominent process, with a truncated posterior surface. This surface has the contour of a heart with its apex downwards, and is divided by a low longitudinal ridge into two slightly excavated surfaces, of which the outer is the smaller. Below, the process passes into a ridge, which runs down upon the middle metatarsal.

The skull is provided with basipterygoid processes, and has an elongated rostrum. The valley between the lamellar maxillo-palatines is both deep and wide.

The lachrymal bones are so completely anchylosed with the frontals and with the broad prefrontal processes, that all traces of their primitive distinctness are completely lost.

The external nares are extremely long and are pervious, the septal ossification not extending between them.

The sternum has, at most, a mere rudiment of the manubrial process; and its posterior margin exhibits either four slight excavations, or two holes externally and two notches internally.

The proximal ends of the clavicles are greatly expanded and recurved; and their outer sides present a deep and wide excavation, at the bottom of which lies the pneumatic foramen. A great part of this excavated surface is left uncovered in front of the clavicular process of the coracoid when the bones are articulated together.

The scapular process of the coracoid is not prolonged forwards to meet the clavicles.

[1] I have examined the skeletons of *Cathartes fœtens*, *C. aura*, and *C. californianus*, of *Sarcorhamphus gryphus* and *S. papa*, and compared them with species of *Neophron*, *Vultur*, *Gyps*, *Gypohierax*, and *Gypaetus*.

The posterior or ischio-iliac edge of the *os innominatum* presents a deep notch, which is not found in the other Aetomorphæ.

No lower larynx is developed.

The group of the *Gypaetidæ* contains the Old World Vultures and the other "*Raptores diurnæ,*" except *Gypogeranus.*

With the single exception of *Pandion* (according to Nitzsch) their contour feathers have aftershafts. The oil-gland is provided with a circlet of feathers.

The phalanges of the hallux, taken together, are much more than half as long as those of the fourth toe; and the articular surface of the metatarsal descends to the level of the other or nearly so.

The second and third phalanges of the fourth toe, taken together, may be longer or shorter than the basal; but the basal phalanx is always much longer than the second.

The basal phalanx of the third toe is longer than the second phalanx, which is sometimes (less commonly) longer, sometimes (more commonly) shorter than the penultimate phalanx.

The tarso-metatarsus is greatly flattened, and its inner edge thin and produced. On the upper part of its posterior face are two ridges (of which the inner is the more prominent) separated by a deep and wide groove.

There are no basipterygoid processes. The maxillo-palatines are more or less spongy; and narrow, or completely obliterate, the intervening valley.

The lachrymals commonly remain long distinct (especially in the Vultures).

The nasal apertures are usually little elongated, and are impervious by reason of the ossification of the septum.

The sternum has a more or less distinctly marked manubrial process. The posterior margin may be entire, and has not more than two holes or notches.

The proximal ends of the strong clavicles are expanded, recurved, and deeply excavated externally; but the large clavicular process of the coracoid fills the whole of the anterior moiety of this excavated surface when the bones are articulated. The scapular process of the coracoid sometimes is [1] and sometimes is not produced to the clavicle.

The inferior larynx is present, and has one pair of intrinsic muscles.

The division of the *Gypogeranidæ* consists of the single genus

[1] *E. g.* in the Falcons proper and in *Polyborus.*

Gypogeranus, which, though allied to the Falcons in some respects, is so peculiar in others that it must be regarded as the type of a family apart. The feathers have an aftershaft, and the oil-gland a circlet (Nitzsch). The phalanges of the elevated hallux, taken together, are not more than half as long as those of the outer toe.

The basal phalanx of the fourth toe is much longer than the distal and longer than the second and third together. These are subequal and very short, shorter than the fourth phalanx.

The basal phalanx of the third toe is much longer than the second· and the second is slightly longer than the third.

The shaft of the long tarso-metatarsal bone is prismatic, its antero-posterior diameter being as great as, or greater than, the transverse. The upper part of its posterior face presents a prominent process terminated by an expanded cordate surface, somewhat as in the *Cathartidæ*.

The skull has basipterygoid processes, and the spongy maxillo-palatines are completely united, so as to obliterate the intermediate valley. The lachrymal remains distinct ; and the long external nares may be pervious, or not, according to the extent of the ossification of the septum. The sternum is escutcheon-shaped, and elongated, The posterior edge is convex, with two small emarginations on each side. There is a distinct manubrial process.

The proximal ends of the clavicles are not expanded, and are hardly excavated. A great median process extends from the symphysis of the clavicles, and becomes anchylosed with the sternum. The scapular process of the coracoid is not prolonged to meet the clavicle.

In the pelvis nothing is to be seen of that bending of the post-acetabular region of the ilium downwards and forwards, which is so strongly marked in most of the other Aetomorphæ.

6. The PSITTACOMORPHÆ.

The rostrum is arched and hooked at the extremity, and is regularly articulated with the frontal region of the skull.

Basipterygoid processes are wanting.

The palatines are vertically elongated posteriorly, while anteriorly they are horizontally flattened and moveably united with the rostrum. The maxillo-palatines are spongy. The lachrymal and the post-orbital bend towards one another and frequently unite below the orbit.

The orbital process of the quadrate bone is very small ; and its

distal end presents only one facet (which is compressed from side to side and convex from before backwards) for the mandible. The rami of the latter are deep, and pass into one another by a rounded truncated symphysis.

The sternum is not notched, but may present two foramina posteriorly.

The clavicles are relatively weak, and may be disunited, or absent. When present, they are concave forwards as well as inwards.

The tarso-metatarsus is very short in relation to the tibia, broad and flattened from before backwards. Its outer distal articular head is divided by a groove into two articular facets.

The fourth toe, articulated with this double facet, is permanently turned backwards. The basal phalanges of the second, third and fourth digits of the foot are shorter than the penultimate.

The inferior larynx has three pairs of muscles, and is, in other respects, peculiar.

The contour-feathers have a large aftershaft, and the oil-gland when present has a circlet.

The Parrots constitute one of the best defined groups of birds, having affinities, though of no very close character, with the Aetomorphæ and the Coccygomorphæ.

7. The COCCYGOMORPHÆ.

The rostrum presents very various forms, and may be moveably articulated with the skull. Basipterygoid processes are present only in one genus (*Trogon*).

The maxillo-palatines are usually more or less spongy. The palatines are not developed into vertical plates, but are, as usual, horizontally flattened.

The distal end of the quadrate bone has the ordinary form.

The sternum usually presents two notches on each side, and has no bifurcated manubrial process (ex. *Merops*).

The clavicles are convex forwards, and without any process developed backwards from the summit of their symphysis.

The tarso-metatarsus is never remarkably elongated.

It does not appear that anything can be predicated in common of the pterylosis or of the characters of the oil-gland in this group.

The larynx has not more than one, or at most two, pair of intrinsic muscles.

The Coccygomorphæ are readily divisible into four groups by the characters of their feet, as follows :—

a. *The first toe turned forwards, as well as the others.*
Coliidæ.

b. *The fourth toe temporarily, or permanently, turned backwards, as well as the first.*

Musophagidæ. *Rhamphastidæ.*
Cuculidæ. *Capitonidæ.*
Bucconidæ. *Galbulidæ.*

c. *The second, third, and fourth toes turned forwards; the first backwards.*

Alcedinidæ. *Meropidæ.*
Bucerotidæ. *Momotidæ.*
Upupidæ. *Coracidæ.*

d. *The first and second toes permanently turned backwards; the third and fourth forwards.*

Trogonidæ.

This group, as I have already intimated, appears to occupy the centre of the Desmognathous division—the *Musophagidæ* approaching the Aetomorphæ, the *Trogonidæ* the Cypselomorphæ, and the *Alcedinidæ* the Pelargomorphæ.

It appears to me not improbable that it may hereafter be desirable to divide this group into four, retaining the title of Coccygomorphæ for the second.

The CELEOMORPHÆ.

The rostrum is straight and usually elongated, and there are no basipterygoid processes.

The maxillo-palatines are short lamellæ, which, when longest, do not extend beyond the outer edges of the palatines, and are sometimes altogether rudimentary.

The vomers are very delicate rod-like bones, which in some cases, at any rate, remain permanently separate.

The quadrate bone is remarkably short.

The sternum has two notches on each side, posteriorly, and a forked manubrial process. The carina extends to the summit of this process, its anterior edge being little (or not at all) excavated.

The clavicles have no median process; but their scapular ends are expanded, as in the typical passerine birds. The *scapula accessoria* has the same form as in the latter.

The upper and posterior process of the tarso-metatarsus is traversed by a number of canals (five in *Picus*) for the flexor tendons; and the outer distal head of the bone is divided into two parts, the fourth toe, which is articulated with it, being turned backwards.

In the second, third, and fourth toes the basal phalanx is shorter than the penultimate.

The tongue is long, slender, and protrusible; and there is only one carotid.

The oil-gland is surmounted by a circlet of feathers.

In this group I comprehend only the *Picidæ* and *Yungidæ*.

It is very difficult to assign the Celeomorphæ to their proper place. Ordinarily they are associated together with the Psittacomorphæ and Coccygomorphæ in the 'order' Scansores; but several ornithologists have pointed out the thoroughly unnatural character of this assemblage; and it is more than thirty years since Sundevall[1] proposed to break it up into the three distinct groups of PICI, PSITTACI, and COCCYGES,—the first to contain *Picus* and *Yunx;* the last *Pogonias*, *Bucco*, *Crotophagus*, *Phænicophæus*, *Coccyzus*, *Centropus*, *Cuculus*, *Galbula*, *Dacelo*, *Merops*, *Colaris*, *Trogon*, and *Caprimulgus*.

Sundevall calls these groups "orders;" but, leaving the question of taxonomic rank aside, the first two exactly correspond with the Celeomorphæ and Psittacomorphæ of the present essay; while the third nearly answers to my Coccygomorphæ,—a coincidence which I the more desire to signalize, as the Swedish naturalist attends only to external characters, while I have, almost exclusively, been guided by the skeleton.

Kessler[1] takes very much the same view as Sundevall, though he is inclined to put *Bucco* along with the Woodpeckers, instead of arranging it, as Sundeville more justly does, with the Cuckoos.

Not that the resemblances pointed out by Kessler do not exist; they are genuine enough, just as are others which might be pointed out between the Woodpeckers and the Hornbills and other Coccygomorphæ; but the structure of the skull affords a very definite and complete distinction between the latter and any of the Gecinomorphæ.

[1] Ornithologiskt System af C. J. Sundevall, Kongl. Vetensk. Akad. Handlingar, 1835, p. 68.

[2] "Beiträge zur Naturgeschichte der Spechte," Bulletin de la Société Impériale des Naturalistes de Moscou, 1844, pp. 331–340.

The Woodpeckers, in fact, are not Desmognathous, the palate in these birds exhibiting rather a degradation and simplification of the Ægithognathous structure. The vomers retain throughout life the condition which is transitory in the Coracomorphæ. With the latter the Celeomorphæ have in common the shortness of the wing-coverts, the conical *scapulæ accessoriæ*, the bifurcate manubrium of the sternum, the multiperforate backward process of the tarso-metatarsus, and the brevity of the basal phalanges of the toes as compared with the penultimate.

Thus I conceive that the Celeomorphæ are intermediate between the Coracomorphæ and the Coccygomorphæ, and that they may be best associated with the former as an aberrant group of the Ægithognathæ, tending towards the Coccygomorphæ as the Cypselomorphæ do in another way.

The other ÆGITHOGNATHÆ are divisible into two groups, the CYPSELOMORPHÆ and the CORACOMORPHÆ.

The CYPSELOMORPHÆ, like the Gecinomorphæ, are annectent forms between the Coracomorphæ and the Coccygomorphæ.

The vomer is truncated at the anterior end, and the maxillo-palatines slender and disposed nearly as in the typical Coracomorphæ (? *Trochilus*).

The sternum is broad and is devoid of a forked manubrium. Its posterior edge may be entire, or may have two excavations on each side.

The furcula has no backwardly directed median process, or only a rudiment of it; and the scapular end of each clavicle is not expanded and T-shaped.

The lower larynx has not more than one pair of intrinsic muscles.

This group contains three very distinct families—the *Trochilidæ*, the *Cypselidæ*, and the *Caprimulgidæ*.

The first two families have a length of the manus and a brevity of the humerus which is peculiar to themselves, being only approached by the Swallows, and in a less degree by the *Caprimulgidæ*. In both *Caprimulgus* and *Ægotheles* the manus is slightly longer than the ulna, and the latter considerably exceeds the humerus in length.

Both the Swifts and the Goatsuckers have a slight rudiment of a vertical process developed from the middle of the furcula. *Ægotheles* approaches the Swifts more nearly than *Caprimulgus* does in the form of its palatine bones, and in the absence of basipterygoid processes.

The *Cypselidæ* are very closely related to the Swallows among the Coracomorphæ, while the *Caprimulgidæ* come near *Trogon*, and more remotely approach *Podargus* and the Owls.

The CORACOMORPHÆ.

There are no basipterygoid processes.

The vomer, single in the adult, is truncated in front and deeply cleft behind.[1] The maxillo-palatines are sometimes slender and rod-like, sometimes broader, but are never concavo-convex lamellæ, or tumid and elongated as in most Schizognathæ. The postero-external angles of the palatines are always well marked, and are frequently produced backwards.

The sternum has a forked manubrium, a strong carina with an excavated anterior edge, long costal processes, and, except in one or two cases (*Pteroptochus* and *Scytalopus*), its posterior edge has a single notch on each side.

The clavicles have expanded T-shaped scapular ends, and send back a vertical process from their inferior junction (except in *Menura*).

There is a conical *scapula accessoria*.

The tarso-metatarsus has a tuberosity perforated by six distinct canals for the flexor tendons.

The pollex is strong and turned backwards.

The basal phalanges are not longer than the penultimate, but usually much shorter in the anterior toes.

The contour feathers have a small aftershaft, and the oil-gland has no circlet of feathers.

There is only one carotid, the left.

The lower larynx presents every degree of complexity. It may be wholly tracheal, or, as is more commonly the case, partly tracheal and partly bronchial; it may be devoid of muscles, or may have six pairs, or may be enveloped in a muscular mass.

This immense group of birds corresponds in great part with the PASSERES of Linnæus and Cuvier, and wholly with the VOLUCRES of Sundevall, who thus defines it:—

Alarum tectrices breves. Pollex validus solus retroversus. Ungues compressi.

Alæ pennis cubiti magnis tectricibusque parvis instructæ; tectrices cubitales minorem quam dimidiam pennarum partem tegunt. Margo alæ plicatæ non a pennis cubiti obtegitur; prima enim

[1] Nitzsch (Art. Passerinæ, Ersch und Grüber's 'Encyclopædie,' 1840) was the first to indicate this and many other distinctive characters of this group.

earum ad ultimam remigum applicata manet. Digiti semper 4. *Pollex crassior vel longior semper volumine major quam digitus internus. Unguis pollicis semper multo major quam laterales sed in quibusdam non major quam medius. Digitus externus toto articulo primo cum digito medio concretus. Phalanx digitorum penultima reliquis multo longior; basales (in digito externo et medio) breves. Cutis pedum firma, arcte applicata, antice scutata. Tarsus scutis 7: mediis longioribus,* 2 *infimis brevissimis superioribus et inferioribus opposita vice obliquis*[1]; *raro plumatus, nunquam reticulatus. Interdum scuta omnia præter* 2 *infima in unum levissimum, suturis obsoletis confluunt (tarsi caligati,* Illiger). *Digiti scutis phalangum* 1 *seu* 2 *longis, juncturarum brevibus. Apparatus musicus laryngis his avibus peculiaris.*

The *Volucres* thus defined are divided into two "orders," as follows:—

Ordo I. PASSERES. *Rostrum crassius conicum capite brevius. Maxilla inferior marginibus validis inflexis convergentibus postice altioribus.*

Rostrum a cranio paullo deflexum exit sutura vix longiore quam dorso rostri. Hinc limes faciei rectus apparet, nec ut in sequentibus ad fauces longe retorsum angulatus. Maxilla inferior ad semina frangenda constructa, ut nuper descriptum qua conformatione in rostro hiante fauces deflexæ apparent. Lingua parva subcrassa plerumque caret margine membranaceo. Rictus mediocris. Pedes minores graciles.

Ordo II. OSCINES. *Rostrum varium marginibus maxillæ inferioris simplicibus nec inflexis.*

Ordo polymorphus et specierum ditissimus cujus descriptio generalis adhuc fere tantum negativa existit.

Now the "Passeres" of Sundevall have all, so far as I have examined them, that peculiar form of the palatine bones which I have described as characteristic of the Finches; while the "Oscines" have the typical Ægithognathous arrangement. And, thus far, cranial characters appear to bear out the classification of Sundevall, though I neither think that the groups have the value he assigns to them, nor that their names are happily selected. It is quite impossible, for example, to restrict a term so commonly used in a wide signification as *Passeres*, to the sense in which Sundevall employs it.

[1] Scuta in *Ptilonorhyncho*, paucis *Myotheris*, *Coracina* et *Chasmorhyncho* 9. In quibus, dam inter longilingues majores 8 parallela, æqualia.

Müller divided the whole of the *Insessores*, according to the structure of the lower larynx[1], into OSCINES or POLYMYODÆ (of which Sundevall's "Passeres" form one family—the *Fringillidæ*), having the lower larynx formed partly by the trachea and partly by the bronchi, and possessing five or six pairs of muscles attached to the ends of certain of the bronchial rings; TRACHEOPHONÆ, with the lower larynx formed exclusively by a modification of the lower part of the trachea; and PICARIÆ, with the larynx either partly tracheal and partly bronchial, or wholly bronchial and with not more than three pairs of muscles.

Under the head of Picariæ, however, Müller included the Cypselomorphæ, Coccygomorphæ, and Psittacomorphæ, as well as the two Ægithognathous families *Tyrannidæ* and *Ampelidæ*; and thus a group of "Picariæ" very different from that of Nitzsch was established.

Later authors, adopting Müller's term of Tracheophonæ, have unfortunately extended the group so named to include the *Tyrannidæ* and *Ampelidæ*, dividing the whole of the "Passeres" into CANORÆ and TRACHEOPHONÆ.

Burmeister, for example, proposes this arrangement in his excellent monograph on *Coracina scutata*, and speaks of that bird as one of the Tracheophonæ; whereas his account of its larynx shows that it is altogether dissimilar to the tracheal lower larynx of the *Myiotheridæ*, *Scytalopodidæ*, and *Anabatidæ*, in which alone that singular structure has been found. Müller would have put *Coracina* among his Picariæ.

If for "Picariæ" we substitute a name formed in a manner analogous to Polymyodæ, viz. OLIGOMYODÆ, the Ægithognathæ would be divisible according to their laryngeal structure into three groups; and it becomes an important question how far the three divisions thus formed are natural, or present other differences beside those of the larynx.

From this point of view, and regarded as primary subdivisions of the Coracomorphæ, it seems to me clear that they are not natural. Burmeister has described *Coracina*; I have examined *Cephalopterus*, *Tyrannus*, *Eurylaimus*, *Pteroptochus*, and *Chasmorhynchus*; and in no one of them does the structure of the skull differ so much from that of a typical polymyodian Coracomorph (*e.g.* one of the Corvidæ) as

[1] Though he wavers in his estimate of the taxonomic value of these divisions. See his paper, "Ueber die bisher unbekannten typischen Verschiedenheiten, &c.," Abhand. d. Berl. Akad. 1846, p. 367.

does that of the also polymyodian *Coccothraustes*. *Pipra* resembles the Finches.

The sternum in most of these genera has the same characters as, and presents no greater varieties than are met with in, the Polymyodæ. But among the Tracheophonæ the small group of *Scytalopodidæ*, as Müller originally stated, have two notches on each side of the sternum, standing alone among the Coracomorphæ in this particular.[1]

So far as their osteology goes, the Polymyodæ, Oligomyodæ, and Tracheophonæ form one great group, in which the Finches and the Scytalopidæ alone are distinguishable from the rest by any very important characters.

But one genus, *Menura*, stands apart from all the other Coracomorphæ.

The vomer in this singular bird is broad and rounded off in front and deeply cleft behind.

The maxillo-palatines are altogether obsolete, or at any rate unossified—a condition which I have not observed in any other Coracomorph.

The sternum has a well-developed and forked manubrium; but its posterior edge is strongly convex, and only exhibits a slight notch on each side. It is unlike the corresponding bone in any of the other Coracomorphæ, in all of which the posterior edge is straight.

The furcula has no median process, and its scapular ends are comparatively little expanded.

The tarso-metatarsus has the typical structure; and the penultimate phalanges are much longer than the basal ones in the anterior toes.

Thus, with my present information, I should be disposed to divide the Coracomorphæ into two primary groups—one containing *Menura*, and the other all the other genera which have yet been examined. How the latter is to be subdivided is a difficult question, upon the consideration of which I do not at present propose to enter.

In concluding this paper, I desire to offer my best thanks to my friends Dr. Günther, Mr. Parker, and Mr. O. Salvin for their kindness in supplying me with specimens, to the Museum Committee of the Royal College of Surgeons, and to Dr. J. E. Gray of the British

[1] In a specimen of *Pteroptochus megapodius* from Chili, in the British Museum, the two notches extend for fully half the length of the sternum, and the middle and outer processes which bound them are very slender. There is a large bifurcated manubrium; and the costal process is long and pointed, being directed forwards and outwards.

Museum for the opportunities of freely employing the collections under their charge which I have enjoyed, and especially to Dr. Sclater for many valuable suggestions upon points of nomenclature.

P.S. I find I have omitted to refer to a memoir by Kessler entitled "Osteologie der Vogelfüsse," published in the "Bulletin de la Société Impériale des Naturalistes de Moscou" in 1841, which is full of valuable information and suggestions. This writer was the first to draw attention to the great systematic value of the tarso-metatarsus and to what I have spoken of as the ratio of length of the phalanges. Kessler's views are fully borne out by M. Alphonse Milne-Edwards in the introduction to his great work on Fossil Birds, now in course of publication.

To the Editor of THE IBIS.

SIR,—While thanking you very heartily for the kind and appreciative criticism of my paper "On the Classification of Birds" which you have published in 'The Ibis' for January last, I should like to be permitted to say a few words in reply.

In the first place let me express my satisfaction that you have drawn attention to Dr. Cornay, who undoubtedly deserves all the merit which may attach to the perception of the classificatory value of the palatine bones. As I have taken occasion to explain privately to Dr. Cornay, it was a matter of much regret to me to find that I had overlooked his paper. My only excuse is, that the many ornithologists (yourself among the number) before whom I had the pleasure of placing my notions, not only when they were brought before the Zoological Society, but on other occasions, seemed to be of one opinion as to their novelty, whatever they might think of their truth.

Next I may be permitted to congratulate myself that you go as far with me as you do, and that, whatever you may think of the method I have employed, you agree in what I regard as the most important results of the application of that method.

For I perceive that you make no objection to the division of the Class *Aves* into the three primary divisions or "Orders" of *Saururæ*, *Ratitæ*, and *Carinatæ*, which are wholly based upon osteological characters.

With respect to the second, however, you remark (p. 91),

"Therefore the single-headedness of the quadrate is not a distinctive character of the *Ratitæ*; and indeed, it seems to me very very doubtful if any of the other so-called 'characters' of the palatal structure are of much greater value in distinguishing between the *Ratitæ* and the *Carinatæ*;" and again (p. 92), "I therefore venture to submit that the palatal structure does not sufficiently furnish Ordinal characters."

But where have I suggested that it does? In giving the characters of the *Saururæ*, the palate is not mentioned, for the good and sufficient reason, that we know nothing about it, if for no other. And, in the characterization of the *Ratitæ* and of the *Carinatæ*, the vomer and palatines occupy a very subordinate place.

I think that in every complete definition of a natural group there are two kinds of characters:—1st, those which are *diagnostic* of the group; and, 2nd, those which are *common* to all its members, and are, so far, characteristic, though they may not be diagnostic. Thus in defining the class *Mammalia*, one does not omit to state that the blood is hot, though the warmth of the blood is not a diagnostic character of that group; and in attempting to define the *Ratitæ* and the *Carinatæ*, characters which are common to all the members of those groups, though they may not be absolutely diagnostic of them, should surely not be omitted.

Further, it must be recollected that the diagnosis of a group may rest not merely on a particular character confined to the group, but on a peculiar combination of characters.

And it may happen that a well-defined group shall not have a single structural feature peculiar to itself, its peculiarity lying entirely in the mode of combination of those features; so that if each one of the seven characters of the *Ratitæ* which I have enumerated were discoverable in some other animal, but in a different state of combination (if I may express myself chemically), I do not think the goodness of the definition would be interfered with.

I quite agree with you, that "a really natural arrangement can only be made out by taking an aggregate of characters"; and, practically, I have endeavoured to express this belief by enumerating seven characters for the *Ratitæ* and three for the *Carinatæ*.

On the other hand, whatever one's notions may be about what is philosophical and what otherwise, it is a matter of fact and everyday experience in zoology, that the modifications of a solitary organ will sometimes afford indications of affinity of great value throughout a whole class, or even subkingdom.

What to an *à priori* speculator could seem more unphilosophical and one-sided than to attempt to arrange the *Vertebrata* according to their occipital condyles, or according to the way in which the lower jaw is connected with the skull? And yet by either of these characters one would be able to assign 999 vertebrate animals out of 1000 to their proper divisions.

Or, again, what can be (theoretically) more open to criticism than the attempt to classify animals by such a "single character" as that of their molar teeth? And yet, am I wrong in saying that if we happened to have no better guide, the character of these teeth would, in a large proportion of cases, give us a very good idea of the affinities of the monodelphous *Mammalia*?

Under these circumstances I do not feel that it is within my "moral competence" (to borrow a phrase from a distinguished personage) to entertain *à priori* objections to the value of a single character for classificatory purposes. The question must, I think, be argued *à posteriori*, and with reference to each particular case. Teeth may be very good marks of affinity among the *Mammalia*, and very bad ones among the *Reptilia*; but their badness in the latter case will not affect their goodness in the former.

Now let me apply all these considerations to the subdivisions of the *Carinatæ*, in which alone, let me remark in passing, have I ascribed a prepotent virtue to palatine characters. In the case of the *Schizognathæ*, I must look upon your objections as a mere unconscious dissembling of affection; for is it not certified under your hand (p. 92)?—

"That the majority of the forms united by Prof. Huxley under the title *Schizognathæ* are in reality very nearly allied, will be denied by no ornithologist, I believe, who thinks for himself."

And again (p. 93):—

"Now on all these points, except one, I had already arrived at opinions closely resembling those of Prof. Huxley, but quite independently of any considerations of the bones of the palate."

Could I ask for better evidence, that the schizognathous skull marks a great natural division of birds as well as, for example, the doubly crescentic molar pattern marks a Ruminant?

In the face of the pleasure that such valuable confirmation of the essential validity of my views gives me, I will not complain of the paragraph which follows—though I do not think that any one who discovered that certain molar teeth are characteristic of the whole of

the *Ruminantia*, might reasonably feel a little hurt in his mind if you told him that you had arrived at the conclusion that they were all one group by studying their horns and hoofs, and that the introduction of these troublesome "characters, drawn from the dental arrangement" might "rather have the effect of complicating and rendering obscure what was simple and clear enough without."

All I can say is, that if you will point out what character, other than the palatine, is common to the assemblage of birds in question, I shall welcome the discovery as the very reverse of a complication or obscuration of ornithic taxonomy.

Before leaving the *Schizognathæ*, however, I am bound to observe that I do not deserve the credit you are kind enough to give me in one matter (p. 92, note). I have found, since my paper was written, that Lherminier, long ago, and more recently Mr. Parker, have strongly insisted on the relationship between the Gulls and the Plovers.

To sum up, I have endeavoured to show:—

1st. That the *Schizognathæ* form a very natural assemblage,—a position which I understand you to admit.

2nd. That the schizognathous structure of the palate is common to, and diagnostic of, all the members of this very large assemblage, with the exception of a very few species belonging to the genera *Crax* and *Dicholophus*. This position also is not disputed on your part.

3rd. Nothing else approaching the nature of a common, still less of a diagnostic character for this great group has yet been discovered.

I assume that you will assent to this proposition also. And, in that case, I really do not see what foundation is left for the rejection of the group *Schizognathæ* as a primary subdivision or suborder of the *Carinatæ*.

I think as much could be said on similar grounds for the *Dromæognathæ*, the *Ægithognathæ*, and the *Desmognathæ*, though it must undoubtedly be admitted that the four natural assemblages[1] of birds which compose the last-named suborder are far less closely united together than those which make up the division of the *Schizognathæ*.

All classification by logical categories, such as that which I have

[1] That is to say, 1. the *Chenomorphæ*, *Amphimorphæ*, *Pelargomorphæ*, *Dysporomorphæ*; 2. the *Aetomorphæ*; 3. the *Psittacomorphæ*; and 4. the *Coccygomorphæ*.

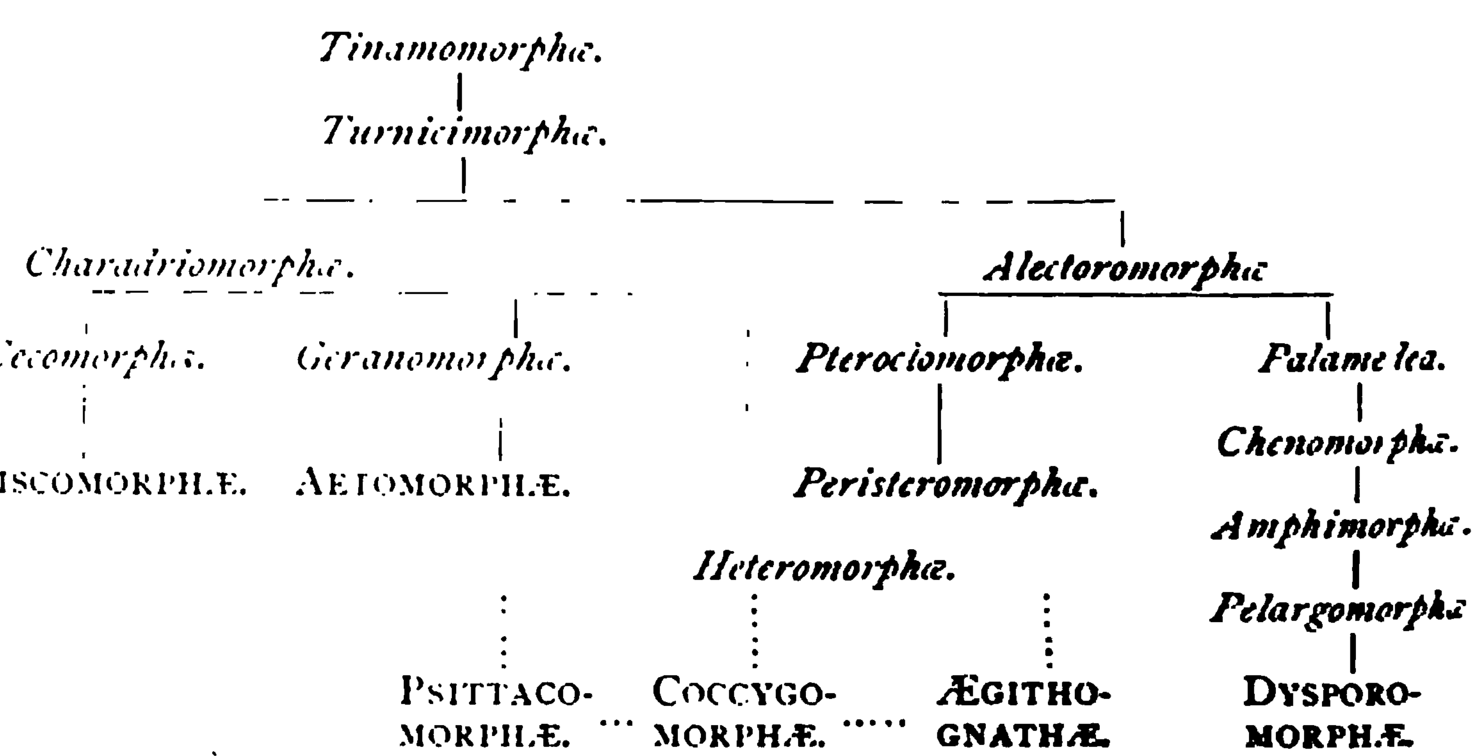
attempted in birds, however, is more or less artificial, and must be regarded as simply a first and most important stage in the progress towards the ultimate goal, which is a *genetic classification*,—a classification, that is, which shall express the manner in which living beings have been evolved one from the other.

Classification by gradation, and the formation of natural series, is another stage in the same progress, and must by no means be confounded, as it often is, with the ultimate result—though, in all probability, it represents a true genetic classification more nearly than any other arrangement can do.

I believe that the broad outlines of such a gradational classification of Birds may be sketched out with tolerable accuracy, even though the details may have to be a good deal modified by subsequent research. Thus I take it to be demonstrated that the *Tinamomorphæ* are those carinate birds which approach nearest the *Ratitæ*; and I think it may be shown that the great majority of the *Carinatæ* fall into one or other of the four series, which diverge directly, or indirectly, from the *Tinamomorphæ* as a common centre.

Thus *Turnix* leads from the *Tinamomorphæ* to the *Charadriomorphæ*; and from the latter two series start—the one commencing with the Gulls and ending in the highly modified Penguins, the other commencing with the Bustards and Cranes, and ending in the highly modified *Aetomorphæ*. On the other hand *Turnix* leads to the *Alectoromorphæ*, which is also the starting-point of two series—the one commencing in *Palamedea*, including the *Chenamorphæ*, *Amphimorphæ*, *Pelargomorphæ*, and culminating in the highly specialized *Dysporomorphæ*; the other beginning in *Syrrhaptes* and passing on to the *Peristeromorphæ*.

These series would stand thus, the names of the most differentiated groups being in capitals.—



I do not think that any one who will examine the facts will be disposed to doubt that this scheme nearly represents the affinities of the groups in question. The great difficulty is to determine the relations of the *Coccygomorphæ*, *Psittacomorphæ*, and *Ægithognathæ* to these; and I have ventured to indicate those relations only in the most doubtful and hypothetic fashion.

Ever yours very faithfully,

T. H. HUXLEY.

From "The Ibis," for July, 1868.

XIV

ON *SAUROSTERNON BAINII*, AND *PRISTERODON M^cKAYI*, TWO NEW FOSSIL LACERTILIAN REPTILES FROM SOUTH AFRICA.

Geological Magazine, vol. v., 1868, *pp.* 201–205.

PLATES XI., XII. [PLATES 23 and 24].

SOME time since Prof. T. Rupert Jones directed my attention to a curious fossil in the British Museum, obtained by Mr. Bain from Styl Krantz, Sniewe Berg, South Africa. The matrix is of the same nature as that in which the Dicynodonts are so commonly found, and exhibits the greater part of the skeleton, but unfortunately not the skull, of a *Lacertilian* reptile, not more than seven or eight inches in length. It is represented of the natural size in Plate XI. [Plate 23], Fig. 1. The trunk is about two and a half inches long, and appears to have attained hardly more than one-third the length of the tail, which is bent round into three-quarters of a circle, and consists of vertebræ, which are very stout near its root, but become attenuated at its termination (*a*). The centra of these vertebræ appear to have been slightly constricted in the middle, and are about one-tenth of an inch in length. The anterior caudal vertebræ present strong and long transverse processes. The dorsal vertebræ can hardly have been fewer than eighteen or twenty, and seem also to have possessed hour-glass shaped centre. They are for the most part provided with long curved ribs, the hindermost four or five pair of which become gradually shorter. One or two vertebræ in front of the sacrum may have been devoid of ribs.

Both the fore and the hind limbs are in place, though but imperfectly preserved. The impression of the large semilunar coracoids

(Figs. 1 and 2 *b*) which meet, and perhaps overlap in the middle line, is very distinct. But one of the most interesting features of the fossil, and that which best indicates its relation with the typical *Lacertilia*, is the great T-shaped, or rather crossbow shaped, episternum or interclavicle (Figs. 1 and 2, *c*), which in its general form and properties closely resembles that of the existing Monitors. The clavicles themselves are not to be distinctly made out. The humerus is equal to about 7 vertebræ in length, and possesses a cylindrical shaft which is moderately expanded at each end. The radius and ulna are rather shorter than the humerus. The manus (Fig. 2 *d*) has slender digits, some of which were certainly terminated by claws, and which seem to have been present in the full number of five. The impression of the pelvis is distinctly visible, though its details cannot be clearly made out. The femur is a long and strong bone, not notably dilated at either extremity. The tibia is stouter than the fibula; both bones are considerably shorter than the femur. The total length of the leg without the foot is 1·8 inch; that of the fore-limb without the manus is 1·4 inch. The foot represented as twice the size of nature, in Fig. 3, seems to have been penta-dactyle, with slender digits, the largest of which could hardly have been shorter than the tibia.

Our knowledge of the characters of the trunk and of the limbs of the Dicynodonts is very defective, but the limb-bones of this skeleton are so unlike any of the corresponding bones which are known among the Dicynodonts, that I think there can be little doubt that the fossil is not the trunk of *Dicynodon*. On the other hand, it is in many respects curiously like *Telerpeton*, and I am disposed to think that the little African reptile, which may be called *Saurosternon Bainii*, was really allied to that famous Lacertian.

At the International Exhibition held at Paris last year, Mr. McKay, of British Kaffraria, exibited a model of "East London and the Harbour Works at the Mouth of the Buffalo River, British Kaffraria, Cape of Good Hope," with some geological sections. The latter are thus described :—

"EXPLANATION OF GEOLOGICAL SECTIONS. (Figs. 1 & 2.)"

"A.—Is a Permian formation, most probably of the age equivalent to the Magnesian Limestone of England and Zechstein of Germany. Its freshwater origin is inferred from the total absence of Marine remains, particularly shells—and the presence of multitudes of remains of reptiles capable of existing on land or freshwater—together with the remains of land-plants in the erect position in which they grew.

D.—Is a wind-stratified Post-Tertiary formation which fringes the coast for a considerable distance (it has been traced from the Kowie to Natal), but does not extend any distance inland, generally under a mile. It is, in fact, nothing more than consolidated sand hills, which, in some places, attain a height of 200 feet and upwards. The hillocks of loose sand that skirt the coast at the present day are identical in composition, stratification, and organic remains.

E.—Is a stiff, reddish yellow clay, with a considerable proportion of calcareous matter: pellets and nodular concretions of lime are dispersed throughout it. It occupies all the depressions in the surface of A, and, in consequence, is very irregular in thickness, ranging from 5 to 150 feet. No fossils have yet been found in it.

F.—A thin layer of ironstone gravel, containing rolled fragments of silicified wood, agate, cornelian, chalcedony, etc.

G.—A rich, dark, earthy clay, from 2 to 5 feet thick, with thin layers of existing marine shells sparingly dispersed in it. These marine remains have been found at an elevation

Fig 1. Hills inside Estuary at the mouth of the Buffalo River, British Kaffraria, Cape of Good Hope. H. Bed of Shells=to H. in Fig. 2.

Fig 2. Order of Super-position of Deposits, Buffalo River.

of 800 feet ("*sic*. in Mr. McKay's MS., at p. 204 he says 200 feet") above the present sea level, so that the land must have been quiescently submerged to that depth within a very recent period.

H This deposit owes its origin to an obstruction across the mouth of the river, which has penned back the water and converted the estuary into a temporary lake, about 20 feet above its present level—three distinct occurrences of this obstruction are plainly seen. After carefully observing most of the mouths of the rivers on our coast, I am satisfied that they are all more or less liable to periodical obstructions of this description.

It is only in this deposit (H) that traces of man have been found. They consist of implements, fragments of native pottery and charred wood.[1] It is only when the fossils are close to the underlying hard rock that the process of concretion and cementation has made any advance, otherwise they are loose in their bed, or are beached up in heaps of loose shells and rubbish in a direction against the sea, as in H, Fig. 1."

[1] Since the above was written, Mr. McKay has discovered a fragment of native pottery in a layer of existing shells in the bed G.

"LIST OF FOSSILS OBTAINED BY MR. McKAY, OF BRITISH KAFFRARIA."

"Bed A.—All the animal remains of this group are presumed to be Reptilian. No. I., Section of Vertebræ. No. 2. Vertebræ and ribs. No. 3. Skull of *Dicynodon*, tusks directed forward, inward, and downward; the mouth and temporal fossæ analogous to the existing turtle. No. 4. Bones of the feet, ribs, etc. No. 5. Part of a Skull. No. 6 and 7. Vertebræ and ribs. No. 8. Jaw with teeth placed in a groove. No. 9. Upper and lower jaw with teeth, one of which is serrated. No. 10. Jaw with teeth in distinct sockets, large teeth to the front, and gradually diminishing in size towards the posterior part of the jaw remarkable for the massiveness of the jaw in proportion to the size of the teeth. No. 11. Small jaw with a row of cylindrical teeth and four supplemental teeth compressed and serrated on the anterior edge only; some elements of the lower jaw. No. 12. Vertebral column of a small reptile; some bones of the legs and sternum. No. 13. Skull with teeth in a groove. No. 14 and 15. Skulls. No. 17. Serrated tooth; two other teeth of this description in my possession are deeply implanted in distinct sockets in a massive jaw; they are serrated on both edges—an attempt was made to clear the serration on the other edge of No. 17, but it was found too brittle, and it shivered with the lightest tap. No. 18. Tooth; the cast of the point of the tooth suggests indentation on the edge of a right angle, rather than projecting serrations; it was associated with No. 17. No. 19. Part of skull and lower jaw teeth, some of which are serrated. Concentric ring-marks are visible in section. No. 20. Rib? No. 21. Tibia? No. 22. Ribs and bones of the feet or paddles? No. 23. Bones of the feet, fragments of the jaw and teeth, etc. Lastly. Many plant impressions, ripple marks, and cast of rain drops.

Bed D.—Existing land shells, casts of existing marine shells, vertebræ of shark, claw of crustacean, bone of land animal, existing marine shells and fragments.

Beds E, and F, are unfossiliferous.

Bed G, contains existing marine shells 220 feet ("*sic* in Mr. McKay's MS., at p. 202 he ys 800 feet") above the present sea-level.

·lded teeth and tusks of *Hippopotamus*; stone ring used by Bushmen. (They are .d on to the pointed sticks as make-weights to assist in digging up roots.) Lastly. .gments of native pottery."

The specimen represented of the natural size in Pl. XII. [Plate 24], Fig. 1, is from Bed A, and is the fossil marked No. 9 in Mr. McKay's list. It is a shattered lacertilian skull, having very much the general shape of that of *Rhynchosaurus*, being very broad posteriorly owing to the large size of the supratemporal fossa (*a*), and tapering anteriorly. The extremity of the snout is broken off. The large orbits (*b*) looking almost directly upwards, lie in the anterior half of the cranium, and are separated by a relatively narrow interorbital space. What appears to be a parietal foramen is situated in the sagittal suture near the truncated occipital margin of the skull. The mandible is very much broken, but what remains of it shows that it was remarkably thick, and that it was provided with teeth, the best preserved of which is represented of twice the natural size in Fig. 1 *a*. Eight or nine such teeth can be counted in relation with the left ramus of the mandible between *d* and *d*. Each of these teeth is straight, flattened from side to side in the crown, but more

cylindrical in the fang, and contains a pulp cavity, which extends nearly to its summit, and is wide in the crown of the tooth. The anterior edge of each tooth is like its surface, smooth and rounded, but the posterior is produced into relatively strong and long denticulations.

The ramus of a mandible of the same animal, is represented of twice the size of nature in Plate XII. [Plate 24], Fig. 2. From the arrangement of the teeth in this and in the foregoing specimen, it appears that they were not disposed in distinct alveoli, but lay close together in a groove of the bony substance of the jaw. The symphysial end of the ramus (*a*) seems to have been devoid of teeth.

The successional teeth are well seen in various stages of development at the bases of those which are fully formed. Most of the latter have been split, or ground down, so as to show their pulp cavities. I propose to name this new Lacertian *Pristerodon McKayi.*

Fig. 3, Plate XII. [Plate 24] is a figure, of the natural size, of another incomplete mandible, similar in its stoutness, and in the apparent absence of teeth from the symphysial region, to the foregoing. But the transverse sections of the fangs of the teeth, which have been exposed, apparently by taking a slice for microscopic purposes, are oval, and show that the pulp-cavity is almost obliterated. The teeth increase in size from behind forwards, and a thin bony septum between the first and second gives rise to a complete alv[illegible] for the first tooth.

The inner side of the ramus gives off a singular slend[illegible] process, which may correspond with the flat and slender pl[illegible] bone which appears to be given off from the inner side of the m[illegible]dible of *Pristerodon*, nearly opposite the lower *d* in Fig. 1, Pl. XII. [Plate 24].

DESCRIPTION OF PLATES XI. AND XII. [PLATES 23, 24].

PL. XI. [Plate 23].—Fig. 1. The impression of the ventral face of *Saurosternon Bainii*, of the natural size. *a*, the extremity of the tail; *b*, the coracoid; *c*, the interclavicle or episterna.

2. A portion of the counterpart. *d*, the manus; *b*, *c*, as before.

3. The left foot; from the counterpart twice the natural size.

PL. XII. [Plate 24].—Fig. 1. The skull of *Pristerodon McKayi*, of the natural size. The greater part of the left half of the skull has split off, leaving the left ramus of the mandible (*c*) exposed. *a*, the right temporal fossa; *b*, the orbit; *d d*, the teeth.

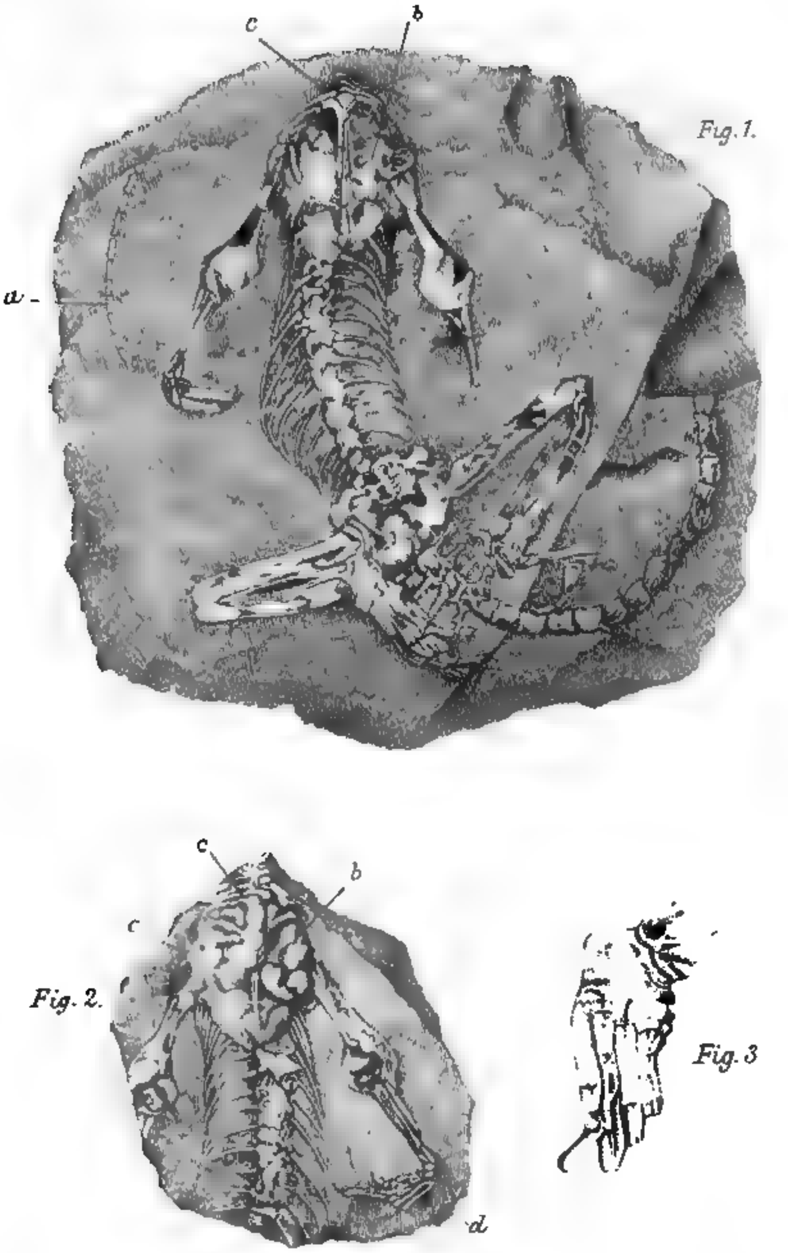
1*a*. A tooth, × 2.

2. A detached ramus of a mandible of *Pristerodon*, viewed laterally, and apparently from the inner side.

3. A similar mandible, viewed from above.

[PLATE 23]

Geol. Mag. 1868. Vol. V. Pl. XI.



A. T. Hollick, del. A. Hammond, lith.

Saurosternon Bainii, Huxley
A New Fossil Reptile from South Africa.

[PLATE 24]

Hollick, del. A. Hammond, lith.

Pristerodon Mc Kayi, Huxley.
A New Fossil Reptile from South Africa.

XV

ON THE ANIMALS WHICH ARE MOST NEARLY INTERMEDIATE BETWEEN BIRDS AND REPTILES.[1]

Geological Magazine, vol. v., 1868, *pp.* 357–365.

THOSE who hold the doctrine of Evolution (and I am one of hem) conceive that there are grounds for believing that the vorld, with all that is in it and on it, did not come into existence in he condition in which we now see it, nor in anything approaching hat condition.

On the contrary, they hold that the present conformation and composition of the earth's crust, the distribution of land and water, and he infinitely diversified forms of animals and plants which contitnte its present population, are merely the final terms in an imnense series of changes which have been brought about, in the ourse of immeasurable time, by the operation of causes more or less imilar to those which are at work at the present day.

Perhaps this doctrine of Evolution is not maintained consciously nd in its logical integrity, by a very great number of persons.[2] But nany hold particular applications of it without committing themelves to the whole; and many, on the other hand, favour the eneral doctrine without giving an absolute assent to its particular pplications.

Thus, one who adopts the nebular hypothesis in Astronomy, or is Uniformitarian in Geology, or a Darwinian in Biology, is, so far, n adherent of the doctrine of Evolution.

[1] Being a Lecture delivered at the Royal Institution of Great Britain, on Friday, ebruary 7, 1868.

[2] The only complete and systematic statement of the doctrine with which I am acquainted that contained in Mr. Herbert Spencer's "System of Philosophy," a work which should be arefully studied by all who desire to know whither scientific thought is tending.

And, as I can testify from personal experience, it is possible to have a complete faith in the general doctrine of Evolution and yet to hesitate in accepting the Nebular, or the Uniformitarian, or the Darwinian hypotheses in all their integrity and fullness. For many of the objections which are brought against these various hypotheses affect them only, and even if they be valid, leave the general doctrine of Evolution untouched.

On the other hand, it must be admitted that some arguments which are adduced against particular forms of the doctrine of Evolution, would very seriously affect the whole doctrine if they were proof against refutation.

For example, there is an objection which I see constantly and confidently urged against Mr. Darwin's views, but which really strikes at the heart of the whole doctrine of Evolution, so far as it is applied to the organic world.

It is admitted on all sides that existing animals and plants are marked out by natural intervals into sundry very distinct groups:—Insects are widely different from Fish—Fish from Reptiles—Reptiles from Mammals—and so on. And out of this fact arises the very pertinent objection,—How is it, if all animals have proceeded by gradual modification from a common stock, that these great gaps exist?

We, who believe in Evolution, reply, that these gaps were once non-existent; that the connecting forms existed in previous epochs of the world's history, but that they have died out.

Naturally enough, then, we are asked to produce these extinct forms of life. Among the innumerable fossils of all ages which exist, we are asked to point to those which constitute such connecting forms.

Our reply to this request is, in most cases, an admission that such forms are not forthcoming, and we account for this failure of the needful evidence by the known imperfection of the geological record. We say that the series of formations with which we are acquainted is but a small fraction of those which have existed, and that between those which we know there are great breaks and gaps.

I believe that these excuses have very great force; but I cannot smother the uncomfortable feeling that they are excuses.

If a landed proprietor is asked to produce the title-deeds of his estate, and is obliged to reply that some of them were destroyed in a fire a century ago, that some were carried off by a dishonest attorney, and that the rest are in a safe somewhere, but that he really cannot lay his hands upon them; he cannot, I think, feel pleasantly secure, though all his allegations may be correct and his ownership indisputable. But a doctrine is a scientific estate, and the holder must

always be able to produce his title-deeds, in the way of direct evidence, or take the penalty of that peculiar discomfort to which I have referred.

You will not be surprised, therefore, if I take this opportunity of pointing out that the objection to the doctrine of Evolution, drawn from the supposed absence of intermediate forms in the fossil state, certainly does not hold good in all cases. In short, if I cannot produce the complete title-deeds of the doctrine of animal Evolution, I am able to show a considerable piece of parchment evidently belonging to them.

To superficial observation no two groups of beings can appear to be more entirely dissimilar than Reptiles and Birds. Placed side by side, a Humming-bird and a Tortoise, an Ostrich and a Crocodile, offer the strongest contrast, and a Stork seems to have little but animality in common with the Snake it swallows.

Careful investigation has shown, indeed, that these obvious differences are of a much more superficial character than might have been suspected, and that Reptiles and Birds do really agree much more closely than Birds with Mammals, or Reptiles with Amphibians. But still, "though not as wide as a church-door or as deep as a well," the gap between the two groups, in the present world, is considerable enough.

Without attempting to plunge you into the depths of anatomy, and confining myself to that osseous system to which those who desire to compare extinct with living animals are almost entirely restricted, I may mention the following as the most important differences between all the Birds and Reptiles which at present exist.

1. The pinion of a Bird, which answers to the hand of a man or to the forepaw of a Reptile, contains neither more nor fewer than three fingers. These answer to the thumb and the two succeeding fingers in man, and have their metacarpals connected together by firm bony union, or anchylosed. Claws are developed upon the ends of at most two of the three fingers (that answering to the thumb and the next), and are sometimes entirely absent.

No Reptile with well-developed forelimbs has so few as three fingers; nor are the metacarpal bones of these ever united together; nor do they present fewer than three claws at their terminations.

2. The breast-bone of a Bird becomes converted into membrane-bone, and ossification commences in it from at least two centres.

The Breast-bone of no Reptile becomes converted into membrane-bone, nor does it ever ossify from several distinct centres.

3. A considerable number of caudal and lumbar, or dorsal, ver-

tebræ unite together with the proper sacral vertebræ of a Bird to form its "sacrum." In Reptiles the same region of the spine is constituted by the one or two sacral vertebræ.

4. In Birds the haunch-bone (ilium) extends far in front of, as well as behind, the acetabulum; the ischia and pubes are directed backwards, almost parallel with it and with one another; the ischia do not unite in the ventral middle line of the body. In Reptiles, on the contrary, the haunch-bone is not produced in front of the acetabulum; and the axes of the ischia and pubes diverge and lie more or less at right angles to that of the ilium. The ischia always unite in the middle ventral line of the body.

5. In all Birds the axis of the thigh-bone lies nearly parallel with the median plane of the body (as in ordinary *Mammalia*) in the natural position of the leg. In Reptiles it stands out at a more or less open angle with the median plane.

6. In Birds one half of the tarsus is inseparably united with the tibia, the other half with the metatarsal bone of the foot. This is not the case in Reptiles.

7. Birds never have more than four toes, the fifth being always absent. The metatarsal of the hallux, or great toe, is always short and incomplete above. The other metatarsals are anchylosed together and unite with one half of the tarsus, so as to form a single bone which is called the *tarsometatarsus*. Reptiles with completely developed hind-limbs have at fewest four toes, the metatarsals of which are all complete and distinct from one another.

Although all existing Birds differ thus definitely from existing Reptiles, one comparatively small section comes nearer Reptiles than the others. These are the *Ratitæ*, or struthious birds, comprising the Ostrich, Rhea, Emu, Cassowary, *Apteryx*, and the but recently extinct (if they be really extinct) birds of New Zealand, *Dinornis*, etc., which attained gigantic dimensions. All these birds are remarkable for the small size of their wings, the absence of a crest or keel upon the breastbone, and of a complete furcula; in many cases, for the late union of the bones of the pinion, the foot, and the skull. In this last character in the form of the sternum, of the shoulder-girdle, and in some peculiarities of the skull, these birds are more reptilian than the rest; but the total amount of approximation to the reptilian type is but small, and the gap between Reptiles and Birds is but very slightly narrowed by their existence.

How far can this gap be filled up by a reference to the records of the life of past ages?

This question resolves itself into two :—

1. Are any fossil Birds more reptilian than any of those now living ?

2. Are any fossil Reptiles more bird-like than living reptiles ? And I shall endeavour to show that both these questions must be answered in the affirmative.

It is very instructive to note by how mere a chance it is we happen to know that a fossil bird, more reptilian in some respects than any now living, once existed.

Bones of birds have been obtained from rocks of very various dates in the Tertiary series without revealing any forms but such as would range themselves among existing families.

A few years ago the great Mesozoic formations had yielded only the few fragmentary ornitholites which have been discovered in the Cambridge Greensand, and which are insufficient for the complete determination of the affinities of the bird to which they belonged.

However, the very fine calcareous mud of the ancient Oolitic sea-bottom which has now hardened into the famous Lithographic slate of Solenhofen, and has preserved innumerable delicate organisms of the existence of which we should otherwise have been, in all probability, totally ignorant, in 1861 revealed the impression of a feather to the famous palæontologist, Herman von Meyer. Von Meyer named the unknown bird to which this feather belonged *Archæopteryx lithographica*, and in the same year, the independent discovery by Dr. Häberlein of the precious skeleton of the *Archæopteryx* itself, which now adorns the British Museum,[1] demonstrated the chief characters of this very early bird. But it must be remembered that this feather and this imperfect skeleton are the sole remains of birds which have yet been obtained in all that great series of formations known as Wealden and Oolite, which partly lie above, partly below, and partly correspond with, the Solenhofen slates.

Though some palæontologists may be forced by a sense of consistency to declare that the class of birds was created in the sole person of *Archæopteryx* during the deposition of the Solenhofen slates, and disappeared during the Wealden, to be re-created in the Greensand, to vanish once more during the Cretaceous epoch and reappear in the Tertiaries, I incline to the hypothesis that many birds besides *Archæopteryx* existed throughout all this period of time, and that we know nothing about them, simply because we do not happen to have hit upon those deposits in which their remains are preserved.

[1] The fossil has been described by Professor Owen in the "Philosophical Transactions" for 1863.

Now, what is this *Archæopteryx* like? Unfortunately, the skull is lost, but the leg and foot, the pelvis, the shoulder-girdle, and the feathers, so far as their structure can be made out, are completely those of existing ordinary birds.

On the other hand, the tail is very long, and more like that of a reptile than that of a bird in this respect. Two digits of the manus have curved claws, much stronger than those of any existing birds; and, to all appearance, the metacarpal bones are quite free and disunited.

Thus it is a matter of fact, that in certain particulars, the oldest known bird does exhibit a closer approximation to reptilian structure than any modern bird.

Are any fossil reptiles more bird-like than those which now exist?

As in the case of birds, the Tertiary formations yield no trace of reptiles which depart from the type of the existing groups. But otherwise than is true of birds, the newest of the Mesozoic formations, the Chalk, makes us acquainted with reptiles, which, at first sight, seem to approach birds in a very marked manner. These are those flying reptiles, the Pterodactyles, which resemble the great majority of birds in the presence of air-cavities in their bones, in the wonderfully bird-like aspect of their coracoid and scapula, and in their broad sternum with its median crest. Furthermore, in some of the Pterodactyles, the premaxillæ and the symphysial part of the mandibles were prolonged into beaks, which appear to have been sheathed in horn, while the rest of each jaw was armed with teeth.

But horn-sheathed beaks are found in reptiles as well as in birds; the structure of the scapulo-coracoid arch and of the sternum, and the pneumaticity of the bones, vary greatly among birds themselves; and these characters of the Pterodactyles may be merely adaptive modifications.

On the other hand, the manus has four free digits, the three inner of which are strongly clawed, while the fourth is enormously prolonged, in total contrast to the abortion of the corresponding digit in birds. The pelvis is as wholly unlike that of birds as is the hind-limb and foot.

Thus it appears that Pterodactyles, among reptiles, approach birds much as Bats, among Mammals, may be said to do so. They are a sort of reptilian Bats[1] rather than links between Reptiles and Birds, and it is precisely in those organs which, in birds, are the most

[1] It will be understood that I do not suggest any direct affinity between Pterodactyles and Bats.

characteristically ornithic, the manus and the pes, that they depart most widely from the ornithic type.

Clearly, then, the passage from Reptiles to Birds is not from the flying Reptile to the flying Bird. Let us try another line. I have already observed that, in the existing world, the nearest approximation to Reptiles is presented by certain land Birds, the Ostriches and their allies, all of which are devoid of the power of flight by reason of the small relative size of their fore-limbs and of the character of their feathers.

Can we find any extinct reptiles which approached these flightless birds, not merely in the weakness of their fore-limbs, but in other and more important characters?

I imagine that we can, if we cast our eyes in what at first sight seems to be a most unlikely direction.

The *Dinosauria*, a group of extinct reptiles, containing the genera *Iguanodon*, *Hadrosaurus*, *Megalosaurus*, *Poikilopleuron*, *Scelidosaurus* *Plateosaurus*, etc., which occur throughout the whole series of the Mesozoic rocks, and are, for the most part, of gigantic size, appear to me to furnish the required conditions.

In none of these animals are the skull, or the cervical region of the vertebral column, completely known, while the sternum and the manus have not yet been obtained in any of the genera. In none has any trace of a clavicle been observed.

With regard to the characters which have been positively determined, it has been ascertained, that :—

1. From four to six vertebræ enter into the composition of the sacrum, and become connected with the ilia in a manner which is partly ornithic, partly reptilian.

2. The ilia are prolonged forwards in front of the acetabulum as well as behind it, and the resemblance to the bird's ilium thus produced is greatly increased by the widely arched form of the acetabular margin of the bone, and the extensive perforation of the floor of the acetabulum.

3. The other two components of the *os innominatum* have not been observed actually in place; indeed, only one of them is known at all, but that one is exceedingly remarkable from its strongly ornithic character. It is the bone which has been called "clavicle" in *Megalosaurus* and *Iguanodan* by Cuvier and his successors, though the sagacious Buckland had hinted its real nature.[1] But these bones are

[1] The so-called "coracoid" of *Megalosaurus* is the ilium. I am indebted to Professor Phillips, and to the splendid collection of Megalosaurian remains which he has formed at Oxford, for most important evidence touching this reptile.

not in the least like the clavicles of any animal which possesses a clavicle, while they are extremely similar to the ischia of such a bird as an ostrich ; and in the only instance in which they have been found in tolerably undisturbed relation with other parts of the skeleton, namely, in the Maidstone *Iguanodon*, they lie one upon each side of the body close to the ilia. I hold it to be certain that these bones belong to the pelvis, and not to the shoulder-girdle, and I think it probable that they are ischia ; but I do not deny that they may be pubes.

4. The head of the femur is set-on at right angles to the shaft of the bone, so that the axis of the thigh-bone must have been parallel with the middle vertical plane of the body, as in birds.

5. The posterior surface of the external condyle of the femur presents a strong crest, which passes between the head of the fibula and the tibia as in birds. There is only a rudiment of this structure in other reptiles.

6. The tibia has a great anterior or "procnemial" crest, convex on the inner, and concave on the outer side. Nothing comparable to this exists in other reptiles, but a correspondingly developed crest exists in the great majority of birds, especially such as have great walking or swimming powers.

7. The lower extremity of the fibula is much smaller than the other ; it is, proportionally, a more slender bone than in other reptiles. In birds the distal end of the fibula thins away to a point, and it is a still more slender bone.

8. *Scelidosaurus* has four complete toes, but there is a rudiment of a fifth metatarsal. The third or middle toe is the largest, and the metatarsal of the hallux is much smaller at its proximal than at its distal end.

Iguanodon has three large toes, of which the middle is the longest. The slender proximal end of a first metatarsal has been found adherent to the inner face of the second, so that if the hallux was completely developed it was probably very small. No rudiment of the outer toe has been observed.

It is clear from the manner in which the three principal metatarsals articulate together, that they were very intimately and firmly united, and that a sufficient base for the support of the body was afforded by the spreading out of the phalangeal regions of the toes.

From the great difference in size between the fore and hind limbs, Mantell, and more recently Leidy, have concluded that the *Dinosauria* (at least, *Iguanodon* and *Hadrosaurus*) may have supported them-

elves, for a longer or shorter period, upon their hind legs. But the iscovery made in the Weald, by Mr. Beckles, of pairs of large three-oed foot-prints, of such a size and at such a distance apart that it is lifficult to believe they can have been made by anything but an *guanodon*, lead to the supposition that this vast reptile, and perhaps thers of its family, must have walked, temporarily or permanently, ipon its hind legs.

However this may be, there can be no doubt that the hind quarters f the *Dinosauria* wonderfully approached those of birds in their eneral structure, and therefore that these extinct Reptiles were more losely allied to birds than any which now live.

But a single specimen, obtained from those Solenhofen slates, to the ccident of whose existence and usefulness in the arts palæontology is o much indebted, affords a still nearer approximation to the "missing ink" between reptiles and birds. This is the singular reptile which ias been described and named *Compsognathus longipes* by the late Andreas Wagner, and some of the more recondite ornithic affinities of vhich have been since pointed out by Gegenbaur. Notwithstanding ts small size (it was not much more than two feet in length), this eptile must, I think, be placed among, or close to, the *Dinosauria*; ut it is still more bird-like than any of the animals which are ordi-iarily included in that group.

Compsognathus longipes has a light head, with toothed jaws, sup-orted upon a very long and slender neck. The ilia are prolonged in ront of and behind the acetabulum. The pubes seem to have been emarkably long and slender (a circumstance which rather favours the nterpretation of the so-called "clavicles" of *Iguanodon* as pubes). The fore-limb is very small. The bones of the manus are unfor-unately scattered, but only four claws are to be found, so that pos-ibly each manus may have had but two clawed digits.

The hind limb is very large, and disposed as in birds. As in the atter class, the femur is shorter than the tibia, a circumstance in vhich *Compsognathus* is more ornithic than the ordinary *Dinosauria*.

The proximal division of the tarsus is ankylosed with the tibia, as n birds. In the foot the distal tarsals are not united with the three ong and slender metatarsals, which answer to the second, third, and ourth toes. Of the fifth toe there is only a rudimentary metatarsal. The hallux is short, and its metatarsal appears to be deficient at its roximal end.

It is impossible to look at the conformation of this strange reptile nd to doubt that it hopped or walked, in an erect or semi-erect osition, after the manner of a bird, to which its long neck, slight

head, and small anterior limbs must have given it an extraordinary resemblance.

I have now, I hope, redeemed my promise to show that, in past times, birds more like reptiles than any now living, and reptiles more like birds than any now living, did really exist.

But, on the mere doctrine of chances, it would be the height of improbability that the couple of skeletons, each unique of its kind, which have been preserved in those comparatively small beds of Solenhofen slate, which record the life of a fraction of Mesozoic time, should be the relics, the one of the most reptilian of birds, and the other of the most ornithic of reptiles.

And this conclusion acquires a far greater force when we reflect upon that wonderful evidence of the life of the Triassic age, which is afforded us by the sandstones of Connecticut. It is true that these have yielded neither feathers nor bones; but the creatures which traversed them when they were the sandy beaches of a quiet sea, have left innumerable tracks which are full of instructive suggestion. Many of these tracks are wholly undistinguishable from those of modern birds in form and size; others are gigantic three-toed impressions, like those of the Weald of our own country; others are more like the marks left by existing reptiles or *Amphibia*.

The important truth which these tracks reveal is, that, at the commencement of the Mesozoic epoch, bipedal animals existed which had the feet of birds, and walked in the same erect or semi-erect fashion. These bipeds were either birds or reptiles, or more probably both; and it can hardly be doubted that a lithographic slate of Triassic age would yield birds so much more reptilian than *Archæopteryx*, and reptiles so much more ornithic than *Compsognathus*, as to obliterate completely the gap which they still leave between reptiles and birds.

But if, on tracing the forms of animal life back in time, we meet, as a matter of fact, with reptiles which depart from the general type to become bird-like, until it is by no means difficult to imagine a creature completely intermediate between *Dromæus* and *Compsognathus*, surely there is nothing very wild or illegitimate in the hypothesis that the *phylum* of the class *Aves* has its root in the Dinosaurian reptiles; that these, passing through a series of such modifications as are exhibited in one of their phases by *Compsognathus*, have given rise to the *Ratitæ*; while the *Carinatæ* are still further modifications and differentiations of these last, attaining their highest specialization in the existing world in the Penguins, the Cormorants, the Birds of Prey, the Parrots, and the Song-birds.

However, as many completely differentiated birds in all proba-

bility existed even in the Triassic epoch, and as we possess hardly any knowledge of the terrestrial reptiles of that period, it may be regarded as certain that we have no knowledge of the animals which linked Reptiles and Birds together historically and genetically; and that the *Dinosauria*, with *Compsognathus*, *Archæopteryx*, and the struthious Birds, only help us to form a reasonable conception of what these intermediate forms may have been.

In conclusion, I think I have shown cause for the assertion that the facts of Palæontology, so far as Birds and Reptiles are concerned, are not opposed to the doctrine of Evolution, but, on the contrary, are quite such as that doctrine would lead us to expect; for they enable us to form a conception of the manner in which Birds may have been evolved from Reptiles, and thereby justify us in maintaining the superiority of the hypothesis, that birds have been so originated to all hypotheses which are devoid of an equivalent basis of fact.

XVI

ON THE FORM OF THE CRANIUM AMONG THE PATAGONIANS AND FUEGIANS, WITH SOME REMARKS UPON AMERICAN CRANIA IN GENERAL.

Journal of Anatomy and Physiology, vol. ii., 1868, *pp.* 253–271.

DR. MORTON, the well-known author of the *Crania Americana*, repeatedly expressed, and throughout his life adhered to, the opinion, that all the people of the two Americas, excepting the Esquimaux, have essentially one physical conformation, and belong to one and the same stock. Thus in the posthumous papers published by Messrs. Nott and Gliddon (*Types of Mankind*, 1854, p. 324), he writes:

". . . . The physical character of the American races from Cape Horn to Canada is essentially the same. There is no small variety of complexion and stature; but *the general form of the skull*, the contour and expression of the face, and the colour and texture of the hair, together with the mental and moral characteristics, all point to a common standard which isolates these people from the rest of mankind."

And at p. 325:

"Every one who has paid attention to the subject is aware that the Peruvian skull is of a rounded form, with a flattened and nearly vertical occiput. It is also marked by an elevated vertex, great interparietal diameter, ponderous structure, salient nose and broad prognathous maxillary region. This is the type of cranial conformation to which all the tribes from Cape Horn to Canada more or less approximate."

However, Dr. Morton somewhat qualifies this expression in the succeeding paragraph:

"I admit that there are exceptions to this rule, some of which I

long ago pointed out in the *Crania Americana*, and others have been recently noticed among the Brazilian Tribes by Professor Retzius."—

This passage was written about 1851. But those who read what follows will hardly allow that it gives an adequate notion of the bearing of Retzius' labours upon American Ethnology, and especially upon Dr. Morton's conclusions. At this time Retzius had, in fact, demonstrated beyond all question the total inaccuracy of these conclusions, so far as the form of the cranium is concerned, by a series of researches, the results of which, published at intervals from 1844 to 1856, appear in the following notices:

1. *Ueber die Form des Knochengerüstes des Kopfes bei verschiedenen Völkern.* Published in 1844. (Retzius' *Ethnologische Schriften*, pp. 27—40).

In speaking of America, Retzius remarks, p. 37:

" In no other part of the world does the shape of the skull show so many definite differences, in none more and greater extremes, and nowhere are the different nations so interspersed among one another. Thus, a few years ago, I received from Professor S. Lovèn the skull of a South Patagonian, which is remarkable for its length, depression and lateral compression. According to the account received this is the predominant form in southern Magalhaen's land, though, on the contrary, the nearest neighbours of this people, the Pampeans or Puelches, have short, broad and higher skulls."

On the following page, Retzius gives a table in which he classifies the Americans as follows:

Gentes dolichocephalæ prognathæ.

Americæ septentrionalis.

Greenlanders and Esquimaux. Kolusches.
Cherokees. Chippeways. Iroquois. Hurons.
Chickesaws. Cayugas. Ottigamies.
Pottowattomies. Lennilenape. Blackfeet.

Americæ meridionalis.

Botocudos. Caribs. Guaranis. Aymaras.
Huanchas. South Patagonians.

Gentes brachycephalæ prognathæ.

Americæ septentrionalis.

Natchez. Creeks. Seminoles. Euchees.
Klatstonis.

Americæ meridionalis.

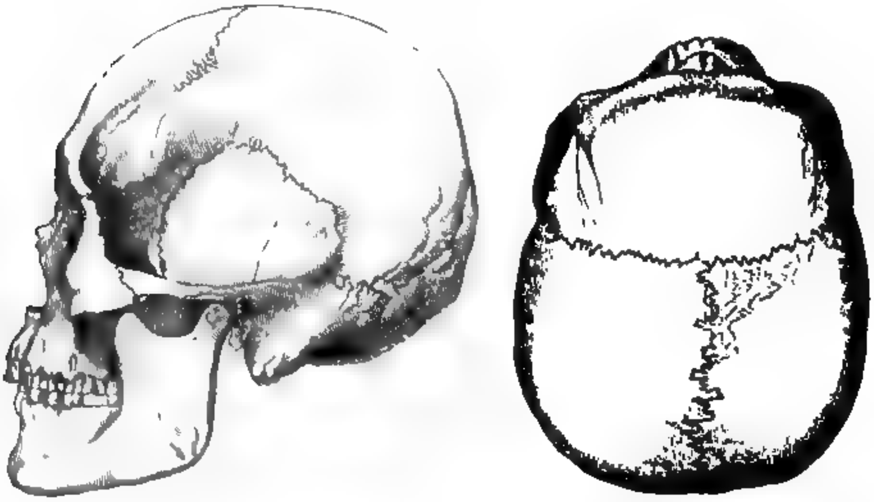
Charruas. Puelches. Araucanians.
Modern Peruvians.

And he adds as doubtful, ***Brachycephalæ orthognathæ***, the Aztecs in Mexico, and the Chincas in Peru.

II. *Beurtheilung der Phrenologie von Anatomisch-Ethnologischen Standpunkte aus.* Published in 1847. (Retzius, *Ethnologische Schriften*, pp. 70—85.)

"Among the *American* races of mankind both dolichocephalic and brachycephalic tribes occur.—Nowhere are such extreme forms to be met with as in the New World, many tribes producing them artificially. The greater part of the Canadian Indians are, so far as I know, dolichocephalic. In the United States both forms occur in different

FIG. 1. FIG. 3.



Figs. 1 and 3. Lateral and upper views of the skull of a Patagonian.

territories . . The Mexican Indians are, for the most part, brachycephalic. Many flatten the skull from behind forwards, whereby it often attains an unnatural shortness and height. . . .

"In Venezuela, Guiana, Brazil, Paraguay, and the neighbouring States, the dolichocephalic form again predominates. To this belong the Caribs, Botocudos, Guaranis, &c. . . .

"In Peru, the Incas, immigrants from Mexico, with especially short and flattened occiputs, are found, besides the Chincas or Yungas, whom Tschudi reckons among the aborigines of the country. According to the same author, there are dolichocephalic tribes, namely the Huanchas and the Aymaras, in Peru. . . .

"The Indians in all the rest of South America, namely the

raucanians in Chili, the Charruas, Puelches, &c. in Uruguay, the a Plata States and Magalhaen's land [1] are, so far as I can discover, l brachycephalic."

III. *Ueber die Schädel-form der Peruaner.* Published in 1848. Retzius, *Ethnologische Schriften*, p. 94).

In this paper Retzius first describes five mummified skulls, which e considers to belong to the Incas, from a tumulus near Pisco, on the oast south of Lima in 13° 46′ S, and 76° 9′ W. All were short, with flat, eeply-inclined, occiputs. The one figured has the cephalic index 0·91.

Three skulls sent from Lima, two of which belonged to complete ummies, on the other hand, are dolichocephalic, that figured having n index of 0·76.

In conclusion, Retzius remarks, p. 98 :—

" In brief, the American peoples in general may, like the nations f the old world, be divided into two principal groups, into brachy-ephali and dolichocephali. To unite these forms under one group, s was formerly done with the Slavonians and Germans, for example, n grounds of philological affinity, is to stray beyond the region of afe natural history fact. Just as in the Old World, the people belonging o these two classes, seem, in many localities, to have lived in small ocieties scattered among one another ; while, in others, they were more harply separated into larger and usually inimical nations, of which ometimes the one and sometimes the other had the upper hand.

" I have, indeed, received a very long and depressed skull of eculiar form, said to come from Magalhaen's land ; but for the resent I hold its origin to be uncertain. Subsequently I have learned om Fitzroy and Darwin's Voyage that even the inhabitants of Tierra el Fuego present the same brachycephalic form as the other Puelches, hence I conclude that this form predominates in the whole southern art of South America.

" The brachycephalic tribes in America form an almost uninter-upted series through the whole western side of this part of the world as far as Cape Horn." . . . .

IV. *Bemerkungen ueber Schädel von Guarani-Indianern aus Brasi-ien.* Published in 1849. (Retzius, *Ethnologische Schriften*, pp. 112—117).

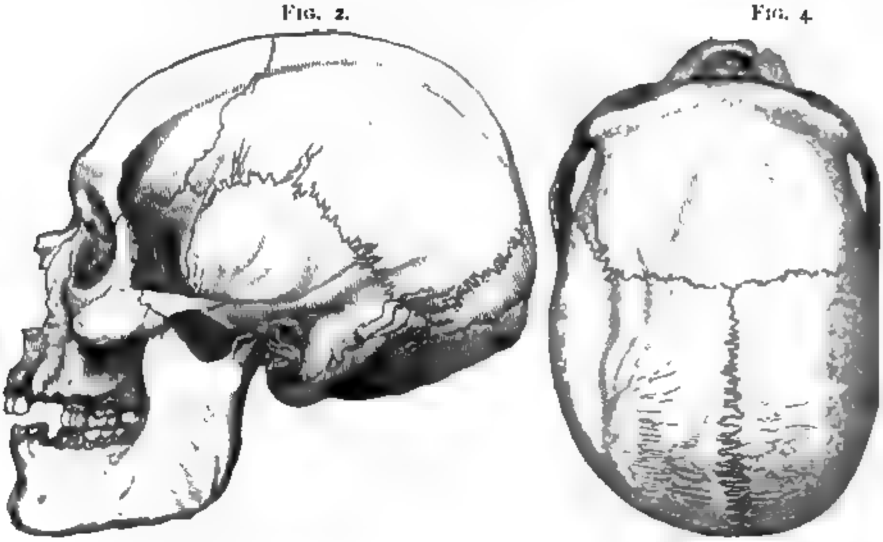
In this memoir the author describes five skulls of "Tapuios" Tupayas), the mean cephalic index of which is 0·70. He mentions wo others of quite the same form, and remarks (p. 116), that he has

[1] This ascription of general brachycephaly to the people of Magalhaen's land is incon-istent with the opinion expressed in the preceding paper. See the third extract.

examined a number of Guarani and Carib skulls, and has never seen a round one. On the contrary, they are all elongated with a very projecting occiput.

Retzius remarks that the D'Orbigny's "Race Brasilio-Guaranienne," to which the "Tapuios," Guaranis and Caribs belong, extends from Guiana to Paraguay, and from the Antilles to the foot of the Bolivian Andes; and he suggests that the Aymaras, whom he regards as the

FIG. 2. FIG. 4.



Figs. 2 and 4. Lateral and upper views of the skull of a Fuegian.

primitive inhabitants of Peru, are of the same stock, laying some stress upon the resemblance between "Aymara" and the name "Aymores" which certain Botocudos give themselves.

V. In the letter to Dr. Nicolucci (1852) (*Ethnologische Schriften*. pp. 120—124), Retzius writes:

"*En Amérique:* Toutes les races de ce continent peuvent être divisées en ces deux mêmes classes, savoir, en brachycéphales et dolichocéphales.

"*Les dolichocéphales* sont dominantes dans la partie orientale. savoir: Les Esquimaux, tous les Américains rouges, les Caraibes dans la Guyane, les Guaraniens au Brésil et au Paraguay, et les petites tribes des Huanches, originaires de Brésil.

"*Les brachycéphales* sont prédominants dans la partie occidentale. savoir: Les Caribiens, les Oregoniens, la plupart des Mexicains, les Chincas au Pérou, les Araucaniens, les Pampéens, les Patagoniens et les Fuegiens."

VI. *Ueber den Schädel eines Pampas Indianers.* Published in 1855. (Retzius, *Ethnologische Schriften*, pp. 131—135.)

In this Essay Retzius describes the brachycephalic skull (the index of which is about 0·88) of a Puelche Indian from the Pampas south of Buenos Ayres. These Indians, he says, extend far south into Magalhaen's Land. The figure of the skull (*l. c.* pl. vi. fig. 7) shews that the occiput has undergone a certain amount of artificial flattening. At the end of this paper the following passage occurs:

"On a previous occasion I drew attention to the general distribution of the brachycephalic and dolichocephalic Indian tribes in America; the dolichocephalic predominating in the eastern, and the brachycephalic in the western parts of the immense American continent. Upon the eastern side we meet with dolichocephali in Labrador and in northern Canada, as Exquimaux; further south as numerous tribes of so-called Red Indians; formerly, in the West Indian islands as Caribs, and still as such in Guiana; as Guaranis, in Brazil and Paraguay. On the western side, the inhabitants of the Kurile islands, and probably of all Russian America; the Chenooks in Oregon, the Aztecs in Mexico, the Incas in Peru, the Araucanians in Chili, the Fuegians in Tierra del Fuego are brachycephalic. But in Magalhaen's land and in the Republic of Buenos Ayres all the Indian tribes are brachycephalic.

"On comparing the skulls of these opposed forms with those of other countries, it appears that the greater number of the eastern Indian tribes approach the Guanches of Teneriffe and the Atlantic people of Africa; the majority of the western Americans, on the contrary, rather resemble the Malayan and Mongolian stocks.

"This division, however, cannot be maintained with perfect strictness. Many tribes have spread in opposite directions, as the dolichocephalic Aymaras and Huanchas in Peru, who probably migrated from Brazil, and as the Creeks, Natchez, and many other brachycephali, eastward of the Rocky Mountains, who probably came from Mexico and California."

VII. The views here expressed are further developed in the eminent Swedish Ethnologist's last and most complete memoir, entitled *Blick auf den gegenwartigen Standpunkt der Ethnologie mit Bezug auf die Gestalt des Knöchernen Schädelgerüstes*, published in 1856. (*Ethnologische Schrfiten*, pp. 136—162.)

In this Essay the author shews that Morton's facts are wholly inconsistent with his hypothesis, that the Americans are of one physical

conformation. "Hardly in any part of the world are there such contrasted dolichocephalic and brachycephalic forms as in America," is the conclusion which Retzius draws no less from Morton's observations than from his own. He repeats the conviction, at which he arrived in 1842 (and which is unquestionably correct), that the Greenlanders and Esquimaux are dolichocephalic, and very different from the Mongols; and he directs attention to the close resemblance between the crania of the Esquimaux and of the Tunguses. Further, Retzius finds that the Chinese skulls very nearly approach those of the Tunguses and Greenlanders. In connection with this subject he observes:

"According to this view, the stock to which the Esquimaux belong would only be Arctic in North America, but from its thinly inhabited area in the Islands of the Arctic Sea and the northernmost parts of America, it extends from west to east to China, of which it constitutes the proper Chinese population, which is to be carefully distinguished from the Tartar-Chinese."

Retzius had not seen an Aleutian skull, but he is disposed to regard the Aleutians as the connecting tribes of the Asiatic and American branches of this stock.

Repeating his views as to the relationship between the Guaranis and the Guanches, Retzius extends them so far as to include the Berbers and the Copts, and even the Jews, in the same category (*l. c.* p. 154), and seems not indisposed to call to his aid the old speculation touching the Atlantis to account for the wide distribution of this "Guarani-Hebrew" stock.

Retzius next proceeds to develope his already hinted hypothesis respecting the relation of the American brachycephali to the people of the South Sea islands and of Asia (*l. c.* p. 155), without adding much new matter. One passage however must be cited:

"I have seen no skulls of Indians from Tierra del Fuego, but I have examined the excellent profile portraits given in Capt. Fitzroy's 'Voyage.' From these portraits it is seen that the Indians of Tierra del Fuego, the Fuegians, are even more brachycephalic than the Pampeans." p. 158.

Nevertheless, on the chart appended to the *Ethnologische Schriften* there is a small red spot on the south coast of Tierra del Fuego, which should indicate the presence of dolichocephali in that region.

Professor Wilson, in his recently published work, *Prehistoric Man*,

confirms the general conclusions of Retzius, with whose , however, he does not appear to have been fully acquainted. ;ives measurements of 37 skulls of Western Canada Hurons, l from "graves to the north of the watershed between Georgian l lakes Erie and Ontario" (Tab. IX. p. 468), of 10 Iroquois Tab. X. p. 470), of 32 Canadian Algonquins (Tab. XI. p. 471), ew England crania (Tab. XII. p. 473), and of 23 Algonquin crania (Tab. XIII. p. 476), of 22 " American brachycephali " II. p. 461), and of 31 " American dolichocephali " (Tab. VI. p. ıaking 185 crania of the uncivilised North American tribes in › these, Prof. Wilson adds (Tab. VIII. p. 464) the measurements eads of twelve living Algonquins. With two exceptions (Nos.) these last are brachycephalic, the average cephalic index of ›le twelve being 0·82–3, and I am at a loss to know why Prof. calls them dolichocephali (*l. c.* pp. 466 and 471), the cephalic which result from his own measurement of the longitudinal ınd parietal (P.D.) diameter being as follows:

No.	L.D. in.	P.D. in.	Index
1	7·4	6·0	·81
2	7·1	6·0	·84
3	7·3	5·8	·79
4	7·5	6·1	·81
5	6·9	6·0	·86
6	7·1	6·0	·86
7	7·4	5·8	·78
8	7·2	5·9	·83
9	7·2	6·0	·83
10	7·3	5·9	·82
11	7·2	6·0	·83
12	7·4	6·6	·89

ıilar errors have crept into his other tables. Thus, of his :an dolichocephali, Nos. 2, 3, 5, 11, and 23 are brachycephali the American brachycephali, Nos. 3, 4, 5, 6, 18, 21, 22 are ›cephali. The Canada Algonquins are said at p. 471 to be all ›cephali, but Nos. 1, 2, 3, 4, 5, 6, 17, 23, 25, 28, and 32 are cephali.

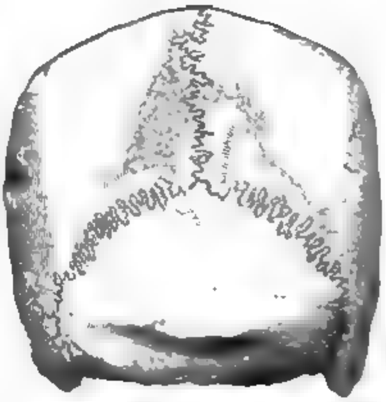
/ising Prof. Wilson's tables, I find that of the 197 crania referred /e, the measurements of which he gives, 145 are dolichocephali brachycephali. Almost all the skulls of the latter class are Algonquin, Canada Algonquin, Algonquin Lenape, or belong

to the following tribes, Muskagees, Dacotahs, Pawnees, Chetimachees, Chimayans, Osages, Creeks, Seminoles, Ottigamies, or Menominees. No Huron skull is brachycephalic, and only one Iroquois in ten, and that a female. Of the New England crania the same proportion, or only 3 in 30, are brachycephalic.

Prof. Wilson gives the measurements of 21 crania from ancient mounds and caves in the valley of the Mississippi. It does not appear that these have been subjected to artificial compression greater than

FIG. 5.

FIG. 7.



Figs. 5 and 7. Facial and occipital views of the skull of a Patagonian.

that resulting from the use of the cradle-board, but they are all brachycephalic, and often eminently so, the average cephalic index being ·87.

So far as these observations extend, therefore, they tend to the conclusion that the ancient inhabitants of the, valley of the Mississippi were brachycephali, and did not artificially flatten their skulls ; a conclusion which is in harmony with the character of the heads represented in the terra-cotta works of that people. All the ancient Mexican and central American terra-cotta heads I have seen represent strongly flattened skulls.

That some of the ancient inhabitants of Mexico had naturally dolichocephalic skulls appears obvious from Prof. Wilson's Table IV. p. 458 ; but it is not so clear that any of them were naturally brachycephalic, as Prof. Wilson does not give any critical account of the

materials whence his Table V. was drawn up, or figure any of the skulls. What he terms a "normal" skull of a Peruvian child (*l. c.* p. 451, fig. 60), is as obviously distorted by circular compression as the adult skull (*l. c.* fig. 59), which he also appears to consider to be normal, and I therefore hesitate to accept his Tables II. and III. of measurements of brachycephalic and dolichocephalic Peruvian crania as evidence.

Retzius, on the other hand, figures two Peruvian skulls (Pl. V. fig. 6 "Aymara," IV. fig. 5, "Inca Peruviana"), one dolichocephalic and the other brachycephalic, neither of which has been affected, to any important degree, by pressure.

Prof. Wilson fully confirms Retzius' statements respecting the skulls of the Esquimaux and Greenlanders, and adds proof of the important fact that the Tchuktchi of Eastern Asia are similarly dolichocephalic.

In 1866 Dr. Meigs, of Philadelphia, published a paper entitled *Observations upon the Cranial Forms of the American Aborigines*,"[1] which acquires an especial importance from being based chiefly upon the study of Morton's collection. His most important conclusions in connexion with the subject of the present paper are the following:

"(1) That the crania of the aboriginal Americans are divisible into dolichocephalic, mesocephalic, and brachycephalic groups.

"(2) That the dolichocephali greatly preponderate in numbers over the mesocephali and brachycephali.

"(3) That, in the case of the Peruvian skulls in the Academy's collection, however, the short square heads are more numerous than the elongated forms.

"(4) That, in North America, neither dolichocephalic nor brachycephalic tribes, when first known to Europeans, were restricted in their geographical distribution to any particular locality. While the former were scattered over the continent, through all degrees of latitude and longitude, the latter appear to have been, if we may judge from the specimens in the Museum, more numerous about the Great Lakes, at various places in the interior, in the south near the Gulf of Mexico, in the so-called Paduca area, and especially along the north-west coast. In general terms we may say that on the eastern or Atlantic side of the continent the dolichocephali appear to have prevailed, and on the western or Pacific side the brachycephali. This in a great measure seems to have been, and still is, the case in South America.

[1] *Proceedings of the Academy of Natural Science of Philadelphia*, May, 1866.

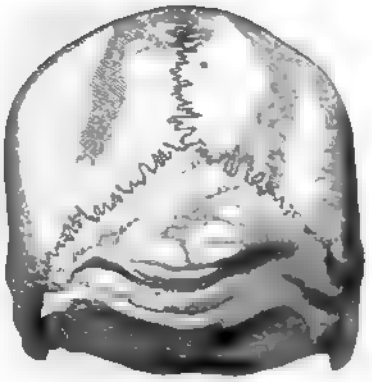
"(5) That long- and short-headed tribes, or races, are very commonly found throughout the two Americas side by side. In the extreme north, for example, dolichocephalic and brachycephalic forms are contrasted in the Esquimaux and their geographical neighbours the Konægi, or Kadiakian Aleutians, and again, in the far south, these diverse forms are exhibited in the Patagonians and Puelches.

"(6) That this contrast in cranial forms existed among the extinct races of America as it now does among extant tribes."

Dr. Meigs, unfortunately, gives no numerical definition of what he means by dolichocephalic, mesocephalic, and brachycephalic, but the

Fig. 6.

Fig. 8.



Figs. 6 and 8. The same views of the skull of a Fuegian.

general tenour of his observations is not the less clear for this uncertainty.

The extensive collection of American skulls which Dr. Meigs studied, appears to have contained no original Patagonian or Fuegian skulls. Two casts are mentioned, one of the short and broad head of a Puelche girl, and the other of the long and cylindrical skull of a Patagonian. I suspect these must have been furnished by Retzius, in which case no dependence can be placed upon the authenticity of the second skull.

The great majority of the American skulls contained in the Museum of the Royal College of Surgeons have been artificially

distorted. But in the following specimens distortion is either absent or slight in amount.

No. 5441.—The cranial part of a skull from the Saltpetre cave, Tennessee. Cephalic index ·73.

No. 5441 A.—The skull of a Messisague or Mohawk Indian, from an old battle-ground at Rice Lake. Cephalic index ·73. The contour of this skull is, in many respects, like that of the Neanderthal fragment.

5441 B.—The skull of a Red Indian from Tennessee, figured by Mr. Busk in the fifth volume of the *Natural History Review*. Cephalic index ·75.

5414 P.—The skull of the squaw of a Creek Indian, Upper Mississippi. Cephalic index ·74. This is an uncompressed prognathous skull with an elongated occiput.

5414 R.—The skull of a Chickasaw, Upper Mississippi. Cephalic index ·78. This skull may have undergone a slight compression at the upper part of the occiput. It is prognathous.

The most interesting of these dolichocephalic skulls, in relation to the subject of the present paper, however, is that of a native of Tierra del Fuego, presented by the late Captain Fitzroy, and thus described in the *Catalogue* by Prof. Owen :

"5428. The cranium is sub-elongate, moderately expanded at the parietal bosses, with a narrow and protuberant super-occipital; the forehead is narrow and low. The glabella is prominent and the nasals are produced. The malars are moderately prominent; the jaws prognathous; the chin well-developed. The base of the skull presents paroccipital protuberances, large styliform processes of the sphenoid, and small but distinct Eustachian processes of the petronal. Traces of the maxillo-premaxillary suture remain on the palate. The molar teeth are of moderate size, and are worn on the inner border in the upper jaw and on the outer border in the lower jaw."

This cranium is represented in Figs. 2, 4, 6 and 8. Its cephalic index is ·74. It has not been distorted by pressure, and in its length, in the projection of the occiput, the width of the inter-zygomatic diameter (5·8 in.), the depth of the nasal depression, and the projection of the nasal bones, it presents no small resemblance to the skull of an Esquimaux.

Many of the other bones of the skeleton of this Fuegian are in the collection. The measurement of the principal bones of the limbs

compared with the corresponding bones of an Esquimaux, are as follows:—

	Femur.	Tibia.	Sum of Femur and Tibia.	Humerus.	Radius.	Sum of Humerus and Radius.
Fuegian	16·6	13·8	30·4	11·85	9·5	21·35
Esquimaux	16·75	12·8	29·55	11·35	8·2	19·55

Thus the femora of the two are nearly equal; but the leg of the Fuegian is nearly an inch longer, owing to the greater length of the tibia. And the Fuegian's arm is nearly two inches longer, in consequence of the still more remarkable brevity of the radius in the Esquimaux.

However, it would appear that, in accordance with the statements of voyagers, the stature of the Fuegian was not very different from that of the Esquimaux.

When my friend Dr. Cunningham, now naturalist on board H.M.S. Nassau, sailed for South America, I requested him to avail himself of any opportunity that might present itself for procuring Patagonian and Fuegian skulls. He has been good enough to bear my wish in mind, and not long ago I received a Fuegian and two Patagonian skulls which had been sent home by him, and which, in accordance with Dr. Cunningham's desire, were placed at my disposal by the Hydrographer.

The cranium of the Fuegian was found "lying partially immersed in a pool of water" at Philip Bay, and is in a good state of preservation, except that the nasal bones and the mandible are absent.

The cephalic index of this skull is ·78; so that it is broader than that figured. But as the last molar has not been cut, it is the skull of a young person, and many circumstances lead me to think it may be that of a woman.

It is a curious circumstance that in this skull, as in that in the College of Surgeons, there are very large and prominent "paroccipital processes," which, as the remains of the cartilage which tipped them shews, would have become considerably longer had the owner of the skull reached maturity. The face is distinctly prognathous.

The Museum of the College of Surgeons contains two undoubted Patagonian skulls, brought by the late Admiral Fitzroy from Port Melo on the east coast of Patagonia. They are described in the Catalogue as Male (No. 5426), and Female. (No. 5427). The skull 5426 has the cephalic index ·87. It exhibits no more indications of occipital pressure than might arise from nursing. The skull 5427 is

more flattened in the occipital region, and there are numerous Wormian bones in the lambdoidal suture. Its cephalic index is ·96; and (though I have no doubt that the skull was primitively broad) I am disposed to ascribe this excess of breadth over No. 5426 to artificial distortion arising from the use of the cradle-board. In fact, Fitzroy, in his *Narrative of the Surveying Voyages of H.M.S. Adventure and Beagle*, Vol. II. p. 154, says of the Patagonians:—

"While infants are suckling, the mothers use frames or cradles in which their charges are carried about; they are made of flat pieces of wood, with a few semicircular guards of lath or thin branches, whose ends are fixed into holes in the wood. In such frames, between pieces of guanaco skin, the babies are placed; and while travelling these cradles are hung at the mother's saddle-bows."

For the opportunity of examining a third genuine Patagonian skull, I am indebted to Higford Burr, Esq., to whom it was intrusted by Captain Watson. It was found in a tumulus near the river Chupa, in latitude 43° S., longitude 67° W.

This skull is represented in Figs. 1, 3, 5 and 7.

The occiput is slightly flattened, especially on the right side, but the distortion is not greater than might be produced by nursing. The cephalic index is ·89.

Of the two skulls sent from Patagonia by Dr. Cunningham, one was found "sticking out of a sand-bank in Gregory Bay;" the other was procured in the course of "digging a hole for a flagstaff in the neighbourhood of direction Hills." The latter skull is, unfortunately very fragmentary, and appears to have undergone *post mortem* distortion. But the former is nearly perfect, though it wants the lower jaw.

This skull (which is that of an adult male) shews very distinct evidence of artificial distortion. Not only is the occiput much flattened and unsymmetrical, but the very retreating forehead has such a surface as appears to me could only have been produced by the application of a frontal compress or bandage. Under these circumstances, the cephalic index (·81) is of doubtful value as an indication of the primitive form of the cranium.

The supraorbital ridges are very strongly marked, their real prominence being much exaggerated by the retreat of the forehead. There are no distinct paroccipital processes. The crowns of the teeth are ground down quite flat.

Although the two skulls sent by Dr. Cunningham are from

Patagonia, it does not absolutely follow that they are Patagonian in the ethnological sense. The Caribs were great voyagers, and some may have strayed as far south as the coast of Patagonia, and left their bones in a sand-bank.

The facts which have been adduced, however, clearly tend to the conclusion that brachycephaly obtains among the Patagonians, and dolichocephaly among the proper Fuegians; and therefore that these two types of cranial conformation exist side by side at the southern extremity of America.

There are only two undistorted or little distorted crania of Guarani' Indians in the Museum of the Royal College of Surgeons. Of these, No. 5405, the skull of a Macusi from Guiana, has the cephalic index ·81. No. 5406, the skull of an Arawack, also from Guiana, has the cephalic index ·80. These two skulls, therefore, though actually brachycephalic, are close to the boundary between brachycephaly, and dolichocephaly, and differ very widely in degree from the more brachycephalic Patagonians.

I do not know that any satisfactory evidence exists as to the natural form of the skull in those North American tribes, such as the Chenooks, in which it is artificially flattened. Leaving these out of consideration, strongly marked brachycephaly seems to be restricted in the New World to (1) the ancient inhabitants of the Mississippi Valley, the so-called "Mound-builders"; (2) the Patagonians, and more or fewer of the Southern Americans westward as far as Peru.

Strongly marked dolichocephaly, on the other hand, is found universally among the Esquimaux; greatly predominates among the Northern Red Indians, and the northern inhabitants of South America; and (if one skull is sufficient evidence) is met with in so much of Tierra del Fuego as is inhabited by Fuegians.

Confining ourselves to people with black hair, and yellowish, reddish, or olive-brown complexions—not differing more widely from that of the Americans than the Americans do from one another—we find that dolichocephaly is continued by the Tchuktches (Wilson), the Tunguses (Retzius), the Japanese, the Ainos and the Chinese, into Asia, and terminates at undefined points on the northern and eastern shores of that great continent.

Brachycephaly of a marked kind predominates in the Aleutian Islands (Von Baer), but is probably not to be met with on the Asiatic coast of the Pacific and Indian oceans more northward than Siam, or more southward and westward than the valley of the Ganges.

Westward and northward from Siam, so far as our information at

present goes, people with yellowish-brown complexions, black hair and brachycephalic skulls, extend across central Asia to Lapland. Southward and eastward they abound in the Malay Archipelago, and may be traced into the Samoan islands and the Sandwich islands in Polynesia.

From China and Japan southward and eastward dolichocephalic people with black hair and yellowish or reddish-brown complexions are to be found (as Dyaks) in Borneo. The cranial characters of the Battas of Sumatra are not sufficiently known. Probably they will be found to be dolichocephalic like the Dyaks; and I believe in all the Micronesian and Polynesian islands—constituting the entire population of some of them, such as New Zealand.

Westward, dolichocephaly combined with yellowish or reddish-brown complexion and black hair, appears in a marked form among the inhabitants of the Canary islands, of Cissaharal Africa, and of Egypt; and, not improbably, in former times, extended much further to the north and west than at present.

On either side of the vast belt of people with black hair and eyes, complexions varying from yellow to olive-brown, and skulls of the most extreme proportions—which has thus been traced in occupation of the Americas, of the greater part of the Pacific islands, of Asia, of northern Africa, and perhaps of southern and western Europe, we find other stocks, in some of which the characters of the skull are as apparently variable as in these; while in others, the skull has a singularly unnatural form.

Thus, northwards, in western Asia, in Europe, and sending offshoots into northern Africa and Hindostan, are the Xanthochroi, with fair skins, light hair, and blue eyes; who offer in the Scandinavian and in the south German the extremes of dolichocephaly and of brachycephaly.

On the south, on the contrary, the dark-skinned people with black wavy hair, and black eyes, who primitively inhabited Australia and the Dekhan, are, I believe, invariably dolichocephalic.

The people with black, crisp, or woolly, hair, and black eyes, who inhabit Ultra-saharal Africa, and sundry islands in the Indian and Pacific oceans, and are known as Negroes, Negritos and Bushmen, are almost as invariably dolichocephalic. At least, I know of not more than two or three cases in which the cephalic indices of these people have reached or slightly exceeded ·80.

XVII

ON SOME ORGANISMS LIVING AT GREAT DEPTHS IN THE NORTH ATLANTIC OCEAN.

Quarterly Journal of Microscopical Science, vol. viii., New Series, 1868, *pp.* 203–212.

IN the year 1857, H.M.S. "Cyclops," under the command of Captain Dayman, was despatched by the Admiralty to ascertain the depth of the sea and the nature of the bottom in that part of the North Atlantic in which it was proposed to lay the telegraph cable, and which is now commonly known as the "Telegraph plateau."

The specimens of mud brought up were sent to me for examination, and a brief account of the results of my observations is given in 'Appendix A' of Captain Dayman's Report, which was published in 1858 under the title of "Deep-Sea Soundings in the North Atlantic Ocean." In this Appendix (p. 64) the following passage occurs:

"But I find in almost all these deposits a multitude of very curious rounded bodies, to all appearance consisting of several concentric layers, surrounding a minute clear centre, and looking, at first sight, somewhat like single cells of the plant *Protococcus*; as these bodies, however, are rapidly and completely dissolved by dilute acids, they cannot be organic, and I will, for convenience sake, simply call them coccoliths."

In 1860, Dr. Wallich accompanied Sir Leopold McClintock in H.M.S. "Bulldog," which was employed in taking a line of soundings between the Faröe Islands, Greenland, and Labrador; and, on his return, printed, for private circulation, some "Notes on the presence of Animal Life at vast depths in the Sea." In addition to the coccoliths noted by me, Dr. Wallich discovered peculiar spheroidal bodies, which he terms "coccospheres," in the ooze of the deep-sea mud, and he throws out the suggestion that the coccoliths proceed from the

coccospheres. In 1861, the same writer published a paper in the 'Annals of Natural History,' entitled "Researches on some novel Phases of Organic Life, and on the Boring Powers of minute Annelids at great depths in the Sea." In this paper Dr. Wallich figures the coccoliths and the coccospheres, and suggests that the coccoliths are identical with certain bodies which had been observed by Mr. Sorby, F.R.S., in chalk.

The 'Annals' for September of the same year (1861) contains a very important paper by the last-named writer, "On the Organic Origin of the so-called 'Crystalloids' of the Chalk," from which I must quote several passages. Mr. Sorby thus commences his remarks:

"The appearance of Dr. Wallich's interesting paper published in this magazine (vol. viii, p. 52), in which he alludes to my having found in chalk objects similar to coccoliths, induces me to give an account of my researches on the subject. I do not claim the discovery of such bodies in the chalk, but to have been the first to point out (1) that they are not the result of crystalline action; (2) that they are identical with the objects described as coccoliths by Professor Huxley; and (3) that these are not single separate individuals, but portions of larger cells."

In respect of the statement which I have numbered (1), Mr. Sorby observes:

"By examining the fine granular matter of loose, unconsolidated chalk in water, and causing the ovoid bodies to turn round, I found that they are not flat discs, as described and figured by Ehrenberg, but, as shown in the oblique side view (fig. 5), *concave* on one side, and *convex* on the other, and indeed of precisely such a form as would result from cutting out oval watch-glasses from a moderately thick, hollow glass sphere, whose diameter was a few times greater than their own. This is a shape so entirely unlike anything due to crystalline, or any other force, acting independently of organization—so different to that of such round bodies, formed of minute radiating crystals, as can be made artificially, and do really occur in some natural deposits—and pointed so clearly to their having been derived from small hollow spheres, that I felt persuaded that such was their origin."

Mr. Sorby then states that, having received some specimens of Atlantic mud from me, he at once perceived the identity of the ovoid bodies of the chalk with the structures which I had called coccoliths, and found that, as he had predicted several years before, "the ovoid bodies were really derived from small hollow spheres, on which they occur, separated from each other at definite intervals."

The coccospheres themselves, Mr. Sorby thinks, may be "an independent kind of organism, related to, but not the mere rudimentary form of, Foraminifera."

"With respect to the coccoliths, their optical character proves that they have an extremely fine, radiating, crystalline structure, as if they had grown by the deposition of carbonate of lime on an elongated central nucleus, in accordance with the oval-ringed structure shown in fig. 1 (magnified 800 linear)."

I am not aware that anything has been added to our knowledge of the "coccoliths" and "coccospheres" since the publication of Mr. Sorby's and Dr. Wallich's researches. Quite recently I have had occasion to re-examine specimens of Atlantic mud, which were placed in spirits in 1857, and have since remained in my possession. I have employed higher magnifying powers than I formerly worked with, or than subsequent observers seem to have used, my great help having been an excellent $\frac{1}{12}$th by Ross, which easily gives a magnifying power of 1200 diameters, and renders obvious many details hardly decipherable with the $\frac{1}{8}$th inch objective which I used in 1857.

The sticky or viscid character of the fresh mud from the bottom of the Atlantic is noted by Captain Dayman.[1] "Between the 15th and 45th degrees of west longitude lies the deepest part of the ocean, the bottom of which is almost wholly composed of the same kind of soft, mealy substance, which, for want of a better name, I have called ooze. This substance is remarkably sticky, having been found to adhere to the sounding rod and line (as has been stated above) through its passage from the bottom to the surface—in some instances from a depth of more than 2,000 fathoms."

This stickiness of the deep-sea mud arises, I suppose, from the circumstance that, in addition to the *Globerigina* of all sizes which are its chief constituents, it contains innumerable lumps of a transparent, gelatinous substance. These lumps are of all sizes, from patches visible with the naked eye to excessively minute particles. When one of these is submitted to microscopical analysis it exhibits—imbedded in a transparent, colourless, and structureless matrix—granules, coccoliths, and foreign bodies.

The *granules* vary in size from $\frac{1}{4000}$th of an inch to $\frac{1}{8000}$th, and are aggregated together into heaps of various sizes and shapes (Plate IV. [Plate 25] fig. 1), some having the form of mere irregular streaks, but others possessing a more definitely limited oval or rounded figure (fig. 1 *c*). Some of the heaps attain $\frac{1}{1000}$th of an inch or more

[1] Loc. cit., p. 9.

ı diameter, while others have not more than a third or a fourth of ıat size. The smallest granules are rounded; of the larger, many re biconcave oval discs, others are rod-like,[1] the largest are irregular.

Solution of iodine stains the granules yellow, while it does not ffect the matrix. Dilute acetic acid rapidly dissolves all but the nest and some of the coarsest granules, but apparently has no effect n the matrix. Moderately strong solution of caustic soda causes the ıatrix to swell up. The granules are little affected by weak alkalies, ut are dissolved by strong solutions of caustic soda or potash.

I have been unable to discover any nucleus in the midst of the eaps of granules, and they exhibit no trace of a membranous nvelope. It occasionally happens that a granule-heap contains othing but granules (fig. 1 *a*), but, in the majority of cases, more r fewer coccoliths lie upon, or in the midst of, the granules. In he latter case the coccoliths are almost always small and incom-ıletely developed (fig. 1 *b*, *c*).

The *coccoliths* are exceedingly singular bodies. My own account f them, quoted above, is extremely imperfect, and in some respects rroneous. And though Mr. Sorby's description is a great improve-ıent on mine, it leaves much to be said.

I find that two distinct kinds of bodies have been described by ıyself and others under the name of coccoliths. I shall term one ind *Discolithus*, and the other *Cyatholithus*.

The *Discolithi* (fig. 2) are oval discoidal bodies, with a thick, trongly refracting rim, and a thinner central portion, the greater art of which is occupied by a slightly opaque, as it were, cloud-ke patch. The contour of this patch corresponds with that of he inner edge of the rim, from which it is separated by a trans-arent zone. In general, the discoliths are slightly convex on one ide, slightly concave on the other, and the rim is raised into a rominent ridge on the more convex side, so that an edge view ex-ıibits the appearance shown in fig. 2 *d*.

The commonest size of these bodies is between $\frac{1}{4000}$th and $\frac{1}{000}$th of an inch in long diameter; but they may be found, on he one hand, rising to $\frac{1}{2700}$th of an inch in length, (fig. 2 *f*), nd, on the other, sinking to $\frac{1}{11000}$th (fig. 2*a*). The last ıentioned are hardly distinguishable from some of the granules of he granule-heaps. The largest discoliths are commonly free, but the maller and smallest are very generally found imbedded among the ranules.

The second kind of coccolith (fig. 4 *a*—*m*), when full grown, has

[1] These apparent rods are not merely edge views of discs.

an oval contour, convex upon one face, and flat or concave upon the other. Left to themselves, they lie upon one or other of these faces, and in that aspect appear to be composed of two concentric zones (fig. 4 *d*, 2, 3) surrounding a central corpuscle (fig. 4 *d*, 1). The central corpuscle is oval, and has thick walls; in its centre is a clear and transparent space. Immediately surrounding this corpuscle is a broad zone (2), which often appears more or less distinctly granulated, and sometimes has an almost moniliform margin. Beyond this appears a narrower zone (3), which is generally clear, transparent, and structureless, but sometimes exhibits well-marked striæ, which follow the direction of radii from the centre. Strong pressure occasionally causes this zone to break up into fragments bounded by radial lines.

Sometimes, as Dr. Wallich has already observed, the clear space is divided into two (fig. 1 *e*). This appears to occur only in the largest of these bodies, but I have never observed any further subdivision of the clear centre, nor any tendency to divide on the part of the body itself.

A lateral view of any of these bodies (fig. 4, *f*—*i*) shows that it is by no means the concentrically laminated concretion it at first appears to be, but that it has a very singular and, so far as I know, unique structure. Supposing it to rest upon its convex surface, it consists of a lower plate, shaped like a deep saucer or watch-glass; of an upper plate, which is sometimes flat, sometimes more or less watch-glass-shaped; of the oval, thick-walled, flattened corpuscle, which connects the centres of these two plates; and of an intermediate substance, which is closely connected with the under surface of the upper plate, or more or less fills up the interval between the two plates, and often has a coarsely granular margin. The upper plate always has a less diameter than the lower, and is not wider than the intermediate substance. It is this last which gives rise to the broad granular zone in the face view.

Suppose a couple of watch-glasses, one rather smaller and much flatter than the other; turn the convex side of the former to the concave side of the latter, interpose between the centre of the two a hollow spheroid of wax, and press them together—these will represent the upper and lower plates and the central corpuscle. Then pour some plaster of Paris into the interval left between the watch-glasses, and that will take the place of the intermediate substance. I do not wish to imply, however, that the intermediate substance is something totally distinct from the upper and lower plates. One would naturally expect to find protoplasm between the two plates; and the granular aspect which the intermediate substance frequently possesses is such

as a layer of protoplasm might assume. But I have not been able to satisfy myself completely of the presence of a layer of this kind, or to make sure that the intermediate substance has other than an optical existence.

From their double-cup shape I propose to call the coccoliths of this form *Cyatholithi.* They are stained, but not very strongly, by iodine, which chiefly affects the intermediate substance. Strong acids dissolve them at once, and leave no trace behind; but by very weak acetic acid the calcareous matter which they contain is gradually dissolved, the central corpuscle rapidly loses its strongly refracting character, and nothing remains but an extremely delicate, finely granulated, membranous framework of the same size as the cyatholith.

Alkalies, even tolerably strong solution of caustic soda, affect these bodies but slowly. If very strong solutions of caustic soda or potash are employed, especially if aided by heat, the cyatholiths, like the discoliths, are completely destroyed, their carbonate of lime being dissolved out, and afterwards deposited usually in hexagonal plates, but sometimes in globules and dumb-bells.

The *Cyatholithi* are traceable from the full size just described, the largest of which are about $\frac{1}{1000}$th of an inch long, down to a diameter of $\frac{1}{8000}$th of an inch. Their structure remains substantially the same but those of $\frac{1}{3000}$th of an inch in diameter and below it are always circular instead of oval; the central corpuscle, instead of being oval, is circular, and the granular zone becomes very delicate. In the smallest the upper plate is a flat disc, and the lower is but very slightly convex (fig. 1 *f.*) I am not sure that in these very small cyatholiths any intermediate substance exists, apart from the under or inner surface of the upper disc. When their flat sides are turned to the eye, these young cyatholiths are extraordinarily like nucleated cells; and it is only by carefully studying side views, when the small cyatholiths remind one of minute shirt-studs, that one acquires an insight into their real nature. The central corpuscles in these smallest cyatholiths are often less than $\frac{1}{20000}$th of an inch in diameter, and are not distinguishable optically from some of the granules of the granule-heaps.

The *coccospheres* occur very sparingly in proportion to the coccoliths. At a rough guess, I should say that there is not one of the former to several thousand of the latter. And owing to their rarity, and to the impossibility of separating them from the other components of the Atlantic mud, it is very difficult to subject them to a thorough examination.

The coccospheres are of two types—the one compact, and the other loose in texture. The largest of the former type which I have met with measured about $\frac{1}{1300}$th of an inch in diameter (fig. 6 *e*). They are hollow, irregularly flattened spheroids, with a thick, transparent wall, which sometimes appears laminated. In this wall a number of oval bodies (1), very much like the "corpuscles" of the cyatholiths, are set, and each of these answers to one of the flattened facets of the spheroidal wall. The corpuscles, which are about $\frac{1}{4300}$th of an inch long, are placed at tolerably equal distances, and each is surrounded by a contour line of corresponding form. The contour lines surrounding adjacent corpuscles meet and overlap more or less, sometimes appearing more or less polygonal. Between the contour line and the margin of the corpuscle the wall of the spheroid is clear and transparent. There is no trace of anything answering to the granular zone of the cyatholiths.

Coccospheres of the compact type of $\frac{1}{1700}$th to $\frac{1}{2000}$th of an inch in diameter occur under two forms, being sometimes mere reductions of that just described, while, in other cases (fig. 6, *c*), the corpuscles are round, and not more than half to a third as big ($\frac{1}{11000}$th of an inch), though their number does not seem to be greater. In still smaller coccospheres (fig. 6 *a*, *b*), the corpuscles and the contour lines become less and less distinct and more minute, until, in the smallest which I have observed, and which is only $\frac{1}{1500}$th of an inch in diameter (fig. 6 *a*) they are hardly visible.

The coccospheres of the loose type of structure run from the same minuteness (fig. 7 *a*) up to nearly double the size of the largest of the compact type, viz. $\frac{1}{700}$th of an inch in diameter. The largest, of which I have only seen one specimen (fig. 7, *d*), is obviously made up of bodies resembling cyatholiths of the largest size in all particulars, except the absence of the granular zone, of which there is no trace. I could not clearly ascertain how they were held together, but a slight pressure sufficed to separate them.

The smaller ones (fig. 7 *b*, *c*, and *a*) are very similar to those of the compact type represented in figs. 6, *c* and *d*; but they are obviously, in the case of *b* and *c*, made up of bodies resembling cyatholiths (in all but the absence of the granular zone), aggregated by their flat faces round a common centre, and more or less closely coherent. In *a*, only the corpuscles can be distinctly made out.

Such, so far as I have been able to determine them, then, are the facts of structure to be observed in the gelatinous matter of the Atlantic mud, and in the coccoliths and coccospheres. I have hitherto said nothing about their meaning, as in an inquiry so difficult and

fraught with interest as this, it seems to me to be in the highest degree important to keep the questions of fact and the questions of interpretation well apart.

I conceive that the granule-heaps and the transparent gelatinous matter in which they are embedded represent masses of protoplasm. Take away the cysts which characterise the *Radiolaria*, and a dead *Sphærozoum* would very nearly resemble one of the masses of this deep-sea "Urschleim," which must, I think, be regarded as a new form of those simple animated beings which have recently been so well described by Haeckel in his 'Monographie der Moneren.'[1] I proposed to confer upon this new "Moner" the generic name of *Bathybius*, and to call it after the eminent Professor of Zoology in the University of Jena, *B. Haeckelii*.

From the manner in which the youngest *Discolithi* and *Cyatholithi* are found imbedded among the granules; from the resemblance of the youngest forms of the *Discolithi* and the smallest "corpuscles" of *Cyatholithus* to the granules; and from the absence of any evident means of maintaining an independent existence in either, I am led to believe that they are not independent organisms, but that they stand in the same relation to the protoplasm of *Bathybius* as the spicula of Sponges or of *Radiolaria* do to the soft part of those animals.

That the coccospheres are in some way or other closely connected with the cyatholiths seems very probable. Mr. Sorby's view is that the cyatholiths result from the breaking up of the coccospheres. If this were the case, however, I cannot but think that the coccospheres ought to be far more numerous than they really are.

The converse view, that the coccospheres are formed by the coalescence of the cyatholiths, seems to me to be quite as probable. If this be the case, the more compact variety of the coccospheres must be regarded as a more advanced stage of development of the loose form.

On either view it must not be forgotten that the components of the coccospheres are not identical with the free cyatholiths; but that, on the supposition of coalescence, the disappearance of the granular layer has to be accounted for; while, on the supposition that the coccospheres dehisce, it must be supposed that the granular layer appears after dehiscence; and on both hypotheses, the fact that both coccospheres and cyatholiths are found of very various sizes proves that the assumed coalescence or dehiscence must take place at all periods of development, and is not to be regarded as the final developmental act of either coccosphere or cyatholith.

[1] "Jenaische Zeitschrift," Bd. iv, Heft 1.

And, finally, there is a third possibility—that the differences between the components of the coccospheres and the cyatholiths are permanent, and that the coccospheres are from the first independent structures, comparable to the wheel-like spicula associated in the wall of the "seeds" of *Spongilla*, and perhaps enclosing a mass of protoplasm destined for reproductive purposes.

In addition to *Bathybius* and its associated discoliths, cyatholiths and coccospheres, the Atlantic mud contains—

a. Masses of protoplasm surrounded by a thick but incomplete cyst, apparently of a membranous or but little calcified consistence, and resembling minute *Gromiæ*. It is possible that these are unfinished single chambers of *Globigerinæ*.

b. *Globigerinæ* of all sizes and ages, from a single chamber $\frac{1}{1500}$th of an inch in diameter, upwards. I may mention incidentally that very careful examination of the walls of the youngest forms of *Globigerina* with the $\frac{1}{12}$th leads me to withdraw the doubt I formerly expressed as to their perforation.

In the absence of any apparent reproductive process in *Globigerinæ*, is it possible that these may simply be, as it were, offsets, provided with a shell, of some such simple form of life as *Bathybius*, which multiplies only in its naked form?

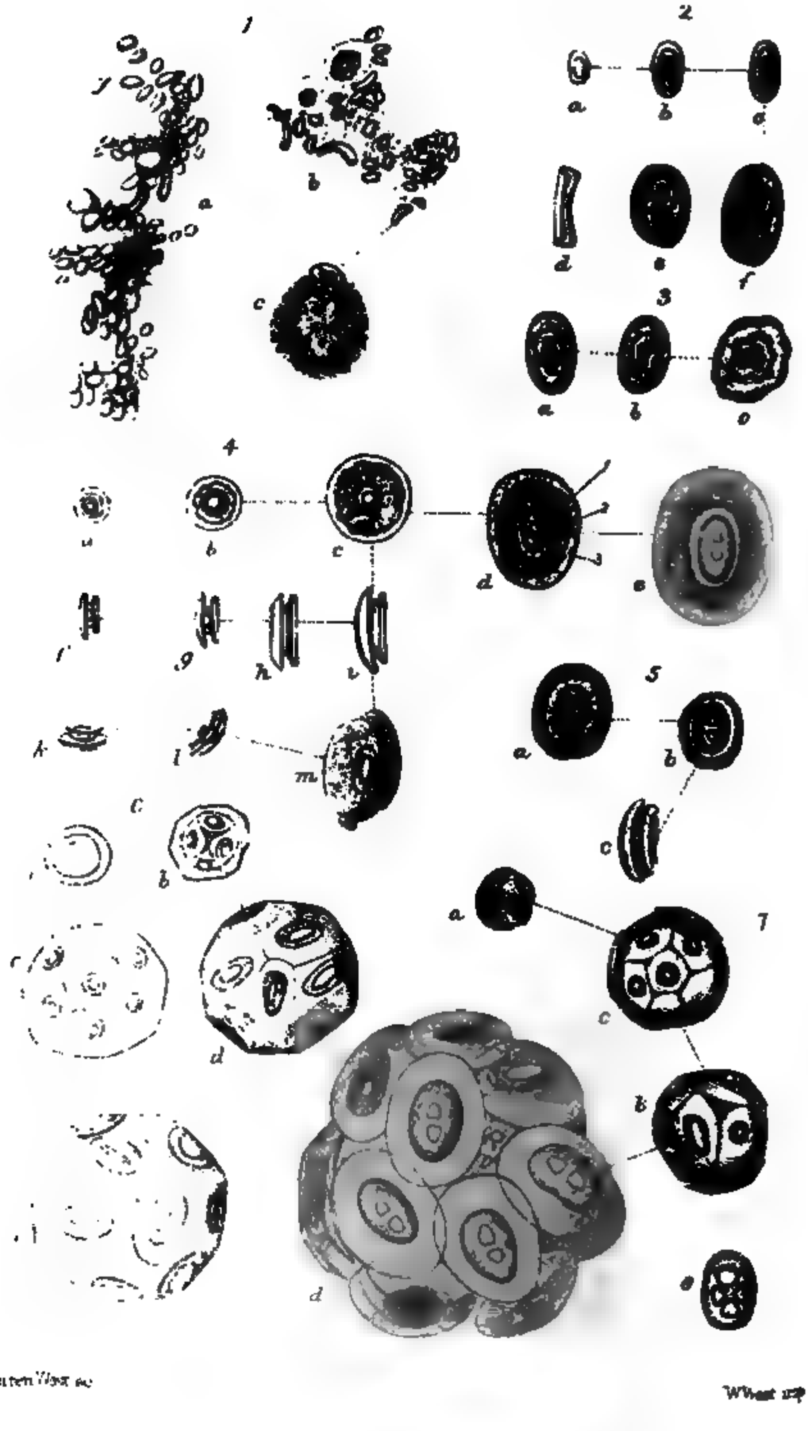
c. Masses of protoplasm enclosed in a thin membrane.
d. A very few *Foraminifera* of other genera than *Globigerina*.
e. *Radiolaria* in considerable numbers.
f. Numerous *Coscinodisci* and a few other Diatoms.
g. Numerous very minute fragments of inorganic matter.

The *Radiolaria* and Diatoms are unquestionably derived from the surface of the sea; and in speculating upon the conditions of existence of *Bathybius* and *Globigerina*, these sources of supply must not be overlooked.

With the more complete view of the structure of the cyatholiths and discoliths which I had obtained, I turned to the chalk, and I am glad to have been enabled to verify Mr. Sorby's statements in every particular. The chalk contains cyatholiths and discoliths identical with those of the Atlantic soundings, except that they have a more dense look and coarser contours (figs. 3 and 5). In fact, I suspect that they are fossilized, and are more completely impregnated with carbonate of lime than the recent coccoliths.

[PLATE 25.]

Micr. Journ. Vol. VIII. N.S. Pl. IV



Tuffen West sc.

W West imp

I have once met with a coccosphere in the chalk ; and, on the other hand, in one specimen of the Atlantic soundings I met with a disc with a central cross, just like the body from the chalk figured by Mr. Sorby (fig. 8).

DESCRIPTION OF PLATE IV. [PLATE 25].

Fig. 1.—Masses of the gelatinous substance.
,, 2.—*Discolithi* from Atlantic mud.
,, 3.— ,, ,, the chalk of Sussex.
,, 4.—*Cyatholithi* from the Atlantic mud.
,, 5.— ,, ,, ,, chalk of Sussex.
,, 6.—Coccospheres of the compact type.
,, 7.— ,, ,, loose type.
,, 8.—A crucigerous disc from Atlantic mud.

All the figures are drawn to the same scale, and are supposed to be magnified 1200 diameters.

XVIII

REMARKS UPON ARCHÆOPTERYX LITHOGRAPHICA

Proceedings of the Royal Society of London, vol. xvi., pp. 243–248.
(*Read January* 30*th*, 1868.)

THE unique specimen of *Archæopteryx lithographica* (von Meyer) which at present adorns the collection of fossils in the British Museum, is undoubtedly one of the most interesting relics of the extinct fauna of long-past ages; and the correct interpretation of the fossil is of proportional importance. Hence I do not hesitate to trouble the Royal Society with the following remarks, which are, in part, intended to rectify certain errors which appear to me to be contained in the description of the fossil in the Philosophical Transactions for 1863[1].

It is obviously impossible to compare the bones of one animal satisfactorily with those of another, unless it is clearly settled that such is the dorsal and such the ventral aspect of a vertebra, and that such a bone of the limb-arches, or limbs, belongs to the left, and such another to the right side.

Identical animals may seem to be quite different, if the bones of the same limbs are compared under the impression that they belong to opposite sides; and very different bones may appear to be similar, if those of opposite sides are placed in juxtaposition.

The following citations, and the remarks with which I accompany them, however, will show that these indispensable conditions of comparison have not been complied with in the memoir to which I refer.

1. "The moiety (Plate I.) containing the greater number of the

[1] "On the *Archæopteryx* of Von Meyer, with a description of the Fossil Remains of a Long-tailed Species, from the lithographic stone of Solenhofen." By Professor Owen, F.R.S., &c.

petrified bones exhibits such proportion of the skeleton from the inferior or ventral aspect" (*l. c.* p. 34).

I propose to show, on the contrary, that the fossilized animal presents, in general, its dorsal aspect to the eye, though one of the most conspicuous bones may have been so twisted round as to exhibit its ventral face.

2. The demonstration that the bones of the *Archæopteryx* are thus wrongly interpreted, may be best commenced by showing that what is called "right femur (65), tibia (66), and bones of the foot (68, *i, ii, iii, iv*)," *l. c.* p. 35, are respectively the left femur, left tibia, and bones of the left foot.

That such is the case is very easily proved by the circumstance that (as is very properly pointed out in the memoir) the second toe of the foot in question is that which lies uppermost, while the plantar surface of the foot is turned outwards, and its dorsal aspect towards the vertebral column.

If the limb in question were, as the describer of the fossil supposes, the right leg, it would obviously be impossible to place the foot in its present position, unless the numbers of the phalanges in its toes were the reverse of what is observed in Birds; that is to say the uppermost toe that which has three phalanges, must also be the outermost. Nevertheless the describer of the fossil justly lays great stress upon the fact that the toes have the same number of phalanges as in birds. As a matter of fact, this is quite true; but it would not be true if we were to assume with him that the limb in question is the right leg.

3. Certain parts of the fossil which lie upon the opposite side of the spine to the so-called "right leg" are named, at p. 34 of the memoir cited, "Portion of the left os innominatum, showing part of the ilium (62) and ischium (63), with the acetabulum (*a*)."

A full description of this mass of bone as "the left os innominatum, including the anterior two-thirds of the ilium, and the anterior half, or more, of the coalesced ischium," is given at p. 39; and at p. 40 I find, "The inferior or central[1] face [of the sacrum], *as in the case of the slightly dislocated left innominatum*, is towards the observer."

There is no doubt on any side, that the end of the bone in question which at present is directed forwards is its true anterior end, and that the edge which is turned towards the spinal column is the true dorsal edge. The question is, whether the face of the bone which is exposed is its outer (or dorsal) or its inner (or ventral) face. In the former case it must needs be a right ilium, in the latter a left ilium.

[1] "Central" in the original. The word appears to have been substituted by an error of the press for "ventral."

That it is the outer face of the bone which lies uppermost appears to me to be demonstrated—

(*a*) By the fact that the iliac margin of the acetabulum is prominent, and that the adjacent surface of this ilium rises to this margin. I am not aware that any vertebrate animal exists in which the acetabulum lies at the bottom of a funnel-shaped depression, such as would be the case in *Archæopteryx* if the bone in dispute were the left os innominatum seen from the inner side.

(*b*) By the fact that a small portion of what appears to be an innominate bone can be descried in close relation with the proximal end of what has just been shown to be the left femur; while the right femur (called left in the memoir), though dislocated, is not very far from the bone under discussion.

(*c*) By the further consideration, that if this were not the right os innominatum, it would be as curiously unlike the corresponding bone of a bird in the form of its surface as it resembles it in all other respects.

4. The bone marked 51′ is named "left scapula" (*l. c.* p. 34), and that marked 51 "right scapular" (*l. c.* p. 35); and a full description of these bones, as such, is given at pp. 36 and 37 of the memoir cited.

Nevertheless I venture to affirm that 51′ is the right scapula and not the left; for it will not be denied that the anterior or glenoidal end of the bone, as it now lies, is directed forwards, its posterior or vertebral end backwards, and its glenoidal articular surface outwards and forwards: it would be quite impossible to put a left scapula of similar construction into this position.

Further, the glenoidal end of the scapula remains in connexion with what is obviously the glenoidal (or humeral) end of the right coracoid (marked *c* in Plate I.). The author of the memoir, indeed, gives a different interpretation of the osseous projection thus marked (*l. c.* p. 37):—

"The prominence beyond the left scapula (Plate I. 51′) suggested at first view the humeral end of the coracoid, but I believe it to be part of the humerus corresponding with the tuberosity on the ulnar side of the sessile semioval head, overarching the pneumatic foramen in the bird."

And this view is pictorially embodied in the restoration of the humerus of *Archæopteryx* given in Plate II. fig. 1.

But a most distinct line of matrix separates the humerus from the prominence in question, in which may be seen, with great clearness, the glenoidal facet of the coracoid, as well as the excavation of the

exterior surface of the bone which is characteristic of the glenoidal or humeral, end of the coracoid in birds and pterodactyles.

I think, then, there can be no question that the parts marked 51′ and *c* in Plate I. of the memoir cited are the right scapula and the glenoidal end of the right coracoid, and not, as the author affirms, the left scapula and a tuberosity of the humerus.

5. Even apart from the fact that the humerus marked 53′ lies in almost undisturbed relation with the right pectoral arch, it is obviously a right humerus. On no other supposition can the relative position of the deltoid ridge and of the various contours of the bone be accounted for. Nevertheless this is called "proximal half of left humerus (53′), entire, and part of the distal half" at p. 34 of the memoir cited.

It is probably needless to pursue this part of the inquiry any further. As the so-called right leg turns out to be the left, the so-called leftos innominatum the right, and the so-called left scapula and wing-bones to be those of the opposite side of the body, the necessity of a corresponding rectification for the other limb-bones needs no evidence.

6. As both the hind limbs and one-half of the pelvis have just such positions as they would readily assume if the hinder part of the animal's body lay upon its ventral face, it is highly improbable (to say the least) that the caudal and posterior trunk-vertebræ should have turned round so as to present their ventral aspect to the eye, as they do according to the memoir (*l. c.* p. 44).

But I apprehend that evidence can be found in the vertebræ themselves sufficient to prove that their dorsal and not their ventral faces are turned towards the eye. In several of the best-preserved of these vertebræ, in fact, (and Plate I. imperfectly shows this,) the remains of two small articular processes are distinctly visible at each end of the vertebra. The superior surface of each articular process is raised into a low longitudinal ridge; and the posterior pair of processes lie at the sides of a narrow, parallel-sided plate of bone, which projects beyond the posterior edge of the vertebra, and is received between the anterior articular processes of the vertebra which succeeds it. A low linear longitudinal elevation occupies the place of spinous process.

If my interpretation of these appearances is correct, it is clear that the caudal vertebræ (as was to be expected) turn their dorsal faces to the eye.

7. One important and extremely conspicuous bone, the furculum (if it be such), undoubtedly turns its ventral surface to the eye; and I

cannot but suspect that it is the *bouleversement* of this bone which has led to that reversal of the proper nomenclature of the other bones which, could it be sustained, would leave *Archæopteryx* without a parallel in the vertebrate subkingdom.

When the specimen of *Archæopteryx* is once put into its right position, many points of its structure acquire an intelligibility which they lose to those who accept the interpretations given in the memoir. The so-called right foot, for example, which, as a right foot, is like nothing in nature, becomes strikingly ornithic as a left foot, from the backward direction of the hallux and the apparent anchylosis of the metatarsal bones. The distal ends of the second and third metatarsals appear to me, however, to be separated for a much greater distance, proportionately to the length of the metatarsus, than in any existing birds, except the Penguins.

The femur is more slender and more curved in proportion to its length than in any recent bird with which I am acquainted. The representation of the bone in fig. 1 of Plate III. is inaccurate, as may be seen by comparing it with that given in Plate I.

The small size of the cnemial crest of the tibia is also very remarkable.

The right innominate bone is imperfectly represented in Plate I. of the memoir cited. Its anterior end is not, as it there appears to be, abruptly truncated : there is an elevation in the region which would be occupied by the prominence against which the base of the great trochanter works, and which is so characteristic of birds. The greater part of the ischium is not represented; and the sacrosciatic space certainly has not the form which it is represented to have. The references *o* to the "obturator foramen," and 63, to the "ischium" (*l. c.* p. 40), are unintelligible to me.

The ischium can be traced back for $\frac{3}{4}$ of an inch from the acetabulum ; and so much of it as is preserved remains narrow throughout this extent, and is convex upwards, but concave downwards or towards the matrix.

The ventral edge of the ischium appears to be entire throughout this extent ; but the posterior moiety of its dorsal edge is somewhat rough and angular. It is therefore very probable that the ischium expanded behind the sacrosciatic notch and united with the ilium, as it very generally does in carinate birds. It is very desirable that this part of the skeleton of *Archæopteryx* should be figured again.

The scapula has a distinct clavicular process, as in carinate birds; and it seems to be pretty clear that the scapula had that

twofold angulation upon the coracoid which is characteristic of the *Carinatæ.*

The glenoidal end of the coracoid is unlike the corresponding part of that bone in any of the *Ratitæ;* but it is more like that of a Pterodactyle than that of any carinate bird which I have met with. It is less prominent (and the counterpart shows that this shortness is not the result of fracture) than in any recent bird, provided with a strong furculum, with which I am acquainted. In fact, in its form, and strength relatively to the shoulder-girdle, the so-called " furculum " appears to me to be the greatest osteological difficulty presented by *Archæopteryx.* I prefer waiting for the light which will be afforded by another specimen to the indulgence of any speculation regarding this bone; in the meanwhile, I by no means wish to deny that appearances are strongly in favour of the interpretation which has been put upon it.

In conclusion, I may remark that I am unaware of the existence of any " law of correlation " which will enable us to infer that the mouth of this animal was devoid of lips, and was a toothless beak. The soft tortoises (*Trionyx*) have fleshy lips as well as horny beaks; the *Chelonia* in general have horny beaks, though they possess no feathers to preen; and *Rhamphorhynchus* combined both beak and teeth, though it was equally devoid of feathers. If when the head of *Archæopteryx* is discovered, its jaws contain teeth, it will not the more, to my mind, cease to be a bird, than turtles cease to be reptiles because they have beaks.

All birds have a tarso-metatarsus, a pelvis, and feathers, such, in principle, as those possessed by *Archæopteryx.* No known reptile, recent or fossil, combines these three characters, or presents feathers, or possesses a completely ornithic tarso-metatarsus, or pelvis. *Compsognathus* comes nearest in the tarsal region, *Megalosaurus* and *Iguanodon* in the pelvis. But, so far as the specimen enables me to judge, I am disposed to think that, in many respects, *Archæopteryx* is more remote from the boundary-line between birds and reptiles than some living *Ratitæ* are.

XIX

ON THE CLASSIFICATION AND DISTRIBUTION OF THE ALECTOROMORPHÆ AND HETEROMORPHÆ.

Proceedings of the Scientific Meetings of the Zoological Society of London, 1868, *pp.* 294–319. (*Read May 14th*, 1868.)

[With a Map.]

THE characters and affinities of the Gallinaceous Birds, or *Alectoromorphæ*, have been discussed within the last few years by two very competent writers—M. Blanchard[1] and Mr. Parker. The memoir "On the Gallinaceous Birds and Tinamous"[2] by the latter author is, in fact, a perfect mine of information for those who do not mind the trouble of digging, and I shall frequently have to express my concurrence with the views therein expressed.

But, in attempting to discover the affinities of *Opisthocomus*, I have been led to believe that a good deal yet remains to be done in the way of defining the limits of the *Alectoromorphæ*, the value of the subdivisions of the group, and the relation of these subdivisions to zoogeography.

I propose to make a contribution towards these objects in the present paper by discussing:—1st, the proper limits of the group *Alectoromorphæ* and of its subdivisions; 2ndly, the relations of sundry outlying forms, commonly regarded as Gallinaceous birds, with the *Alectoromorphæ* and adjacent groups; 3rdly, the geographical distribution of the *Alectoromorphæ* in relation to geographical distribution generally.

[1] "De la détermination de quelques Oiseaux Fossiles et des caractères Ostéologiques des Gallinacés ou Gallides" (Ann. d. Sc. Nat. sér. 4e, 1857, t. vii.).

[2] Transactions of the Zoological Society, vol. v. p. 149 (1864).

I. *The proper limits of the Group* Alectoromorphæ *and of its subdivisions.*

In my paper "On the Classification of Birds"[1] I have included the *Pteroclidæ* and the *Turnicidæ* with the *Phasianidæ*, *Megapodidæ*, and *Cracidæ* in one division, *Alectoromorphæ*, though the aberrant characters of the *Turnicidæ* and *Pteroclidæ* are fully recognised. I am now convinced that it will be much more convenient to restrict the title of *Alectoromorphæ* to the three latter groups, which agree with one another, and differ from the other two in the following osteological characters:—

1. The last cervical vertebra and the anterior dorsals are always anchylosed together in the adult. One of the posterior dorsals (generally, if not always, the penultimate) remains free, while the hindermost becomes ankylosed with the lumbar vertebræ to form part of the so-called "sacrum."

2. The number of the præsacral vertebræ in the different regions of the body is very constantly, if not always, 16 cervical, 5 dorsal, and 3 lumbar. The total number of these vertebræ is therefore 24, or the same as in Man.

3. The maxillo-palatines vary greatly in form and size, and in the degree to which they are ossified, but they are always lamellar or conchoidal. They unite in the middle line with an ossified septum only in some *Cracidæ*.

4. There are oval, sessile basipterygoid facets, situated far forwards upon the rostrum of the sphenoid.

5. The palatines are long and narrow, with obsolete internal laminæ and rounded-off postero external angles.

6. The angle of the mandible is produced and recurved, and the oral margins of the rami are not flanged out.

7. The external xiphoid processes of the sternum (which are much shorter than the internal ones) are bent outwards over the hinder ribs and have expanded ends.

8. The coracoid has no subclavicular process.

9. The scapular end of the furcula is not expanded; but it forms almost the whole, or the greater part, of the inner wall of the canal for the tendon of the middle pectoral muscle. The hypocleidium[2] is well developed, and presents very various shapes.

10. The acromial process of the scapula is very short.

11. The humerus has no supinator spine, and the anterior edge of the deltoid crest is obliquely bevelled off.

[1] Proc. Zool. Soc., 1867, p. 415.

[2] The process developed from the symphysis of the conjoined clavicles.

12. The hypotarsus (commonly called the calcaneal process of the tarso-metatarsus) is traversed by a single canal.

13. The hallux is always present, though it varies greatly in size and position.

The *Alectoromorphæ*, distinguished from all other birds by the totality of these characters, are divisible into two primary groups, which I shall term the *Peristeropodes* and the *Alectoropodes*. In the former division the foot is Pigeon-like, the long hallux being on a level with the other toes; while in the latter it is Fowl-like, the hallux being short and raised.

The *Peristeropodes* have the following osteological characters:—

1. In the sternum the osseous junction of the metosteon with the lophosteon is broad, the inner notch being less than half as long as the sternum itself (fig. 1, p. 349).

2. The pleurostea end in front in short and obtuse "costal processes" (*c. p*, fig. 1), the anterior edges of which are at right angles, or nearly so, with the axes of the sternum.

3. The hallux is on a level with the other toes; and its basal phalanx is about as long as, or may be longer than, that of the third digit.

These characters are diagnostic of the *Peristeropodes*. In addition, the second metacarpal presents no backward process near its proximal end; the phalanx of the third digit of the manus has no basal projection or tubercle; and, in the pelvis, an ileo-pectineal process is generally absent; if present, it is weak. In all those species in which I have been able to observe it, the vomer is strong, and compressed from side to side.

The *Cracidæ* and *Megapodidæ* compose this group. It may excite surprise that birds so unlike in habit should be arranged even in the same division; but I must go further and declare that after a careful examination of the genera *Talegalla*, *Megapodius*, *Crax* (*Pauxi*), *Penelope*, *Oreophasis*, and *Ortalida*, I am at a loss to discover any important *osteological* differences whatever between the *Megapodidæ* and the *Cracidæ*.[1] The hind toe, however, appears to be longer in proportion to the rest, and all the toes in proportion to the tarso-metatarsus, in the *Megapodidæ*.

It is a singular circumstance, however, that the form of the pelvis varies a good deal both in the *Megapodidæ* and in the *Cracidæ*. If we term the moiety of the dorsal aspect of the pelvis which is bounded

[1] In the degree of pneumacity of the bones, the *Cracidæ* and the *Megapodidæ* differ immensely, as Mr. Parker has already shown; but this is a character of no systematic value.

in front by a transverse line drawn through the acetabula the *postacetabular area*, each group will be found to present some forms in which the postacetabular area is broad, and some in which it is relatively narrow.

Thus *Talegalla* has the postacetabular area broad, while *Megapodius* has it narrow.

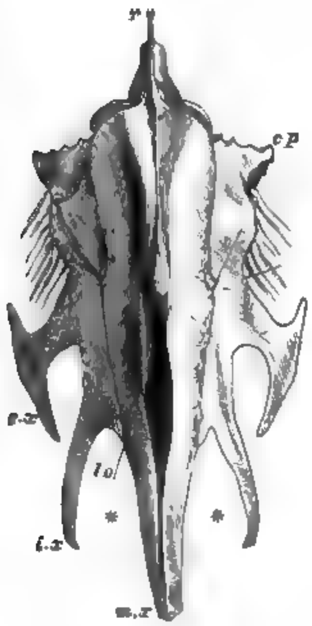


FIG. 1.

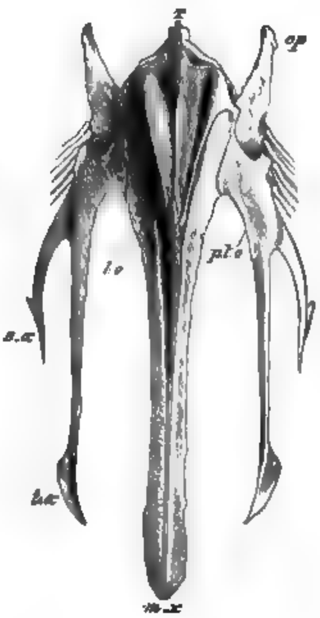


FIG. 2.

Fig. 1. The sternum of *Crax globicera*.—*r*. Rostrum. *c. p.* Costal process. *pl. o.* Pleurosteon. *e. x.* External xiphoid process; and *i. x*, internal xiphoid process of the metosteon. *l. o.* Lophosteon bearing the carina and ending behind in *m. x*, the middle xiphoid process. * * The inner notches.

Fig. 2. The sternum of *Lophophorus impeyanus*. The letters as before, except *pl. o*, metosteon.

The *Penelopinæ* (*Penelope*, *Oreophasis*, *Ortalida*) have the postacetabular area broad; but in the *Cracinæ* (*Crax*, *Pauxi*) it is narrow (figs. 3 and 4, p. 350).

M. Blanchard has already indicated some of the differences between the *Cracidæ* and the ordinary Gallinaceous birds.

"Les types essentiellement Américains, comme les Alectors, c'est à dire les genres *Urax*, *Crax*, et *Penelope*, s'éloignent à quelques égards des types de l'ancien continent; leur crâne est allongé, à côtés presque parallèles, rappellant la forme de la tête des Pigeons; c'est que leur frontaux sont larges, et leurs lacrymaux très-développés,

au lieu d'être rejetés en dehors, sont exactement emboités entre les os nasaux et les frontaux ; ensuite les apophyses temporale et mastoïdienne se trouvent être écartées davantage ; la région parietale est presque plane comme la région frontale ; enfin le vomer est toujours libre et très-développé, ce qui n'a pas lieu dans les autres, où il parait se souder complètement avec la cloison interobitaire. On voit d'après cela que les types Américains se séparent d'une

Fig. 3.

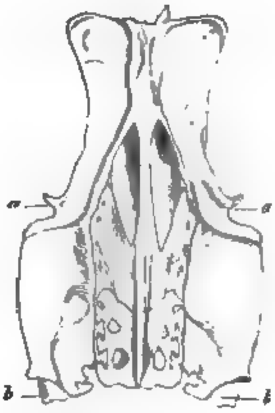


Fig. 4.

Fig. 3. The dorsal aspect of the pelvis of *Crax globicera.*—*a a*. A transverse line drawn through the centres of the acetabula. *b b*. A transverse line drawn through the posterior extremities of the ilia. The area included between these lines is the "*post-acetabular area*."

Fig. 4. A corresponding view of the pelvis of *Penelope cristata.*

manière assez prononcée de tous les autres Gallides, auxquels ils ressemblent cependant par l'ensemble de leurs caractères."—*l. c.* pp. 102, 103.

Mr. Parker has also many valuable remarks upon the *Cracidæ;* but, like M. Blanchard, he leaves out of sight the very intimate relation between this group and the *Megapodidæ.*

In the *Alectoropodes*—

1. The osseous junction of the lophosteon and metosteon is narrow, the inner notch being always more than half as long as the sternum (fig. 2, p. 349).

2. The costal processes of the pleurostea (*c. p*, fig. 2) are more prolonged and more nearly parallel with the axis of the sternum than in the preceding case.

3. The hallux is raised above the level of the other toes, and its basal phalanx is much shorter than that of the third toe.

With a single exception, the second metacarpal always has a backward process.[1] A tubercle is very commonly present upon the posterior edge of the base of the phalanx of the third digit; and the ilio-pectineal processes are generally very well developed. The vomer, wherever I have been able to observe it, has been weak and flattened from above downwards.

Three groups are readily distinguishable by osteological characters among the *Alectoropodes*.

The *Numididæ*[2] differ from the other members of this division in the absence of any backward process of the second metacarpal, and in the obtuseness and somewhat outward inclination of the costal processes. The acromial process of the scapula is also singularly recurved.

In all the rest the backward process of the second metacarpal is distinctly developed, and the costal processes are more acute (generally very much so) and pass more directly forwards. Among these the *Meleagridæ* are peculiar in three respects.

1. The length of the ilium from the centre of the acetabulum to its posterior margin (which may be called the *postacetabular length*) is greater than the distance from the same point to the anterior margin of the ilium (or *præacetabular length*).

2. Viewing the pelvis from above, the postacetabular area is longer than it is broad (fig. 5, p. 352).

3. The furcula is singularly weak and straight (viewed laterally), and has a straight rod-like hypocleidium.

In all the other genera which I have examined, the præacetabular length is greater than, or, in the solitary case of *Tetrao cupido*, equal to, the postacetabular. The postacetabular area is broader than it is long; the lateral contour of the furcula more curved; and the hypocleidium expanded antero-posteriorly.

The great series of Galline, Pavonine, Phasianine, and Tetraonine birds included under the title of *Phasianidæ*, which offer these

[1] M. Blanchard (*l. c.* p. 99) gives the presence of this process as a universal character of the "Gallinacés," merely mentioning that "dans les Hoccos et les Pénélopes elle s'affaiblit beaucoup."

[2] That is to say, the species of the genus *Numida*. I have seen no skeletons of *Agelastus* or *Phasidus*.

characters, present two types of structure, the one of which may be termed *Galline*, and the other *Tetraonine*, and which are well defined and contrasted in their extreme forms, though I am by no means clear that they do not graduate into one another.

In the *Galline* or *Fowl type*—

1. The postacetabular area is moderately broad (fig. 6, p. 353), and the inner and posterior angles of the ilia are produced beyond the level of the last sacral vertebra.

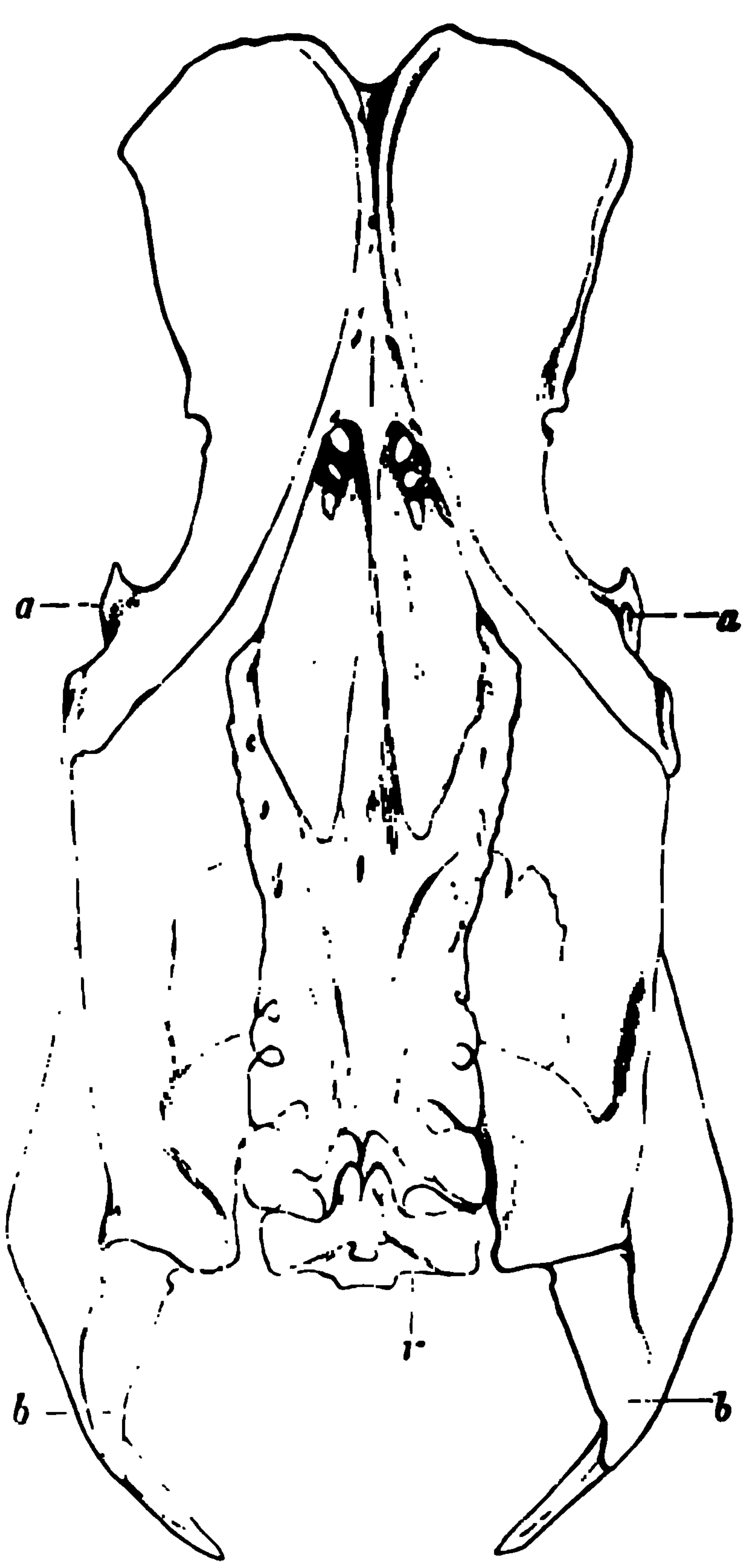


FIG. 5. The dorsal aspect of the pelvis of *Meleagris gallopavo*.
The letters as before. *v*. The last sacral vertebra. (The letters *b b* are placed too far back, as they are likewise, to a less extent, in fig. 7, p. 353.)

2. The ulnar edge of the distal end of the basal phalanx of the second digit is rounded off; and the base of the phalanx of the third digit has no tubercle, or only a small one.

3. The anterior margin of the deltoid crest of the humerus is long and oblique.

4. The hypocleidium is more or less broadly oval in contour, with curved margins.

5. The tarso-metatarsus is more than half as long as the tibia.

6. The mandibular foramen is small.

In the *Tetraonine* or *Grouse type*, on the other hand—

1. The postacetabular region is very broad (fig. 7, p. 353); the ilia are truncated nearly opposite the end of the sacrum, and it is the external angle of the posterior edge of the ilium which is rather the longer.

2. The ulnar and distal edge of the basal phalanx of the second digit is produced; and the phalanx of the third digit has a strong basal tubercle.

3. The anterior margin of the deltoid crest is less oblique, and the angle of the crest is sharper and more prominent.

4. The hypocleidium has straight edges and a triangular form, the apex of the triangle being directed forwards.

5. The tarso-metatarsus is not half as long as the tibia.

6. The mandibular foramen is very large.

The two series of forms meet among the Partridges and Quails—*Perdix*[1] lying on the Tetraonine, *Caccabis*, *Rollulus*, *Francolinus*, and *Coturnix*, on the Galline side of the boundary.

I have not sufficient materials to decide the point; but the *Odontophorinæ* appear to go with *Perdix*.

In the proper *Phasianinæ* (*Phasianus*, *Thaumalea*) and in *Pucrasia*, the pelvis has reached an indifferent point, being neither

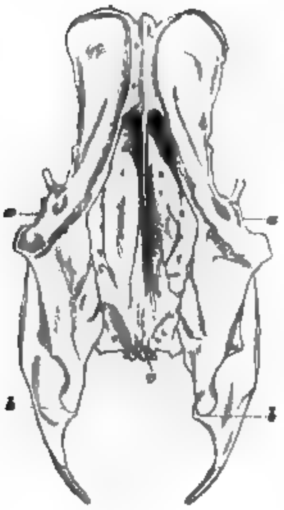


FIG. 6.

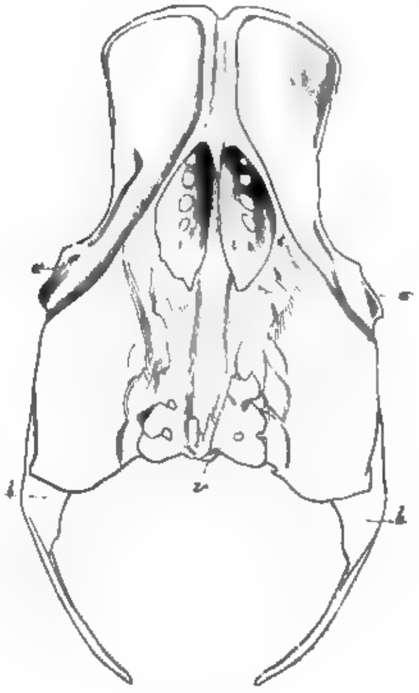


FIG. 7.

Fig. 6. The dorsal aspect of the pelvis of *Gallus domesticus*.
,, 7. The dorsal aspect of the pelvis of *Tetrao urogallus*.
(The letters as before.)

specially Tetraonine nor specially Galline; but that of the *Lophophorinæ* (*Lophophorus*, *Tetraogallus*) is more decidedly Galline.

The Peacocks are the most aberrant forms of this series, from the curious modification of the postacetabular area of the pelvis. The costal processes of the sternum are obtuse and relatively short,

[1] This has already been pointed out by Mr. Parker, "Gallinaceous Birds and Tinamous," Trans. Zool. Soc. v. p. 155).

pterygoid and the basipterygoid processes, on the other hand, are like those of the *Peristeromorphæ.*

3. The sternum and furcula, as well as the coracoid (in its shortness, breadth, and the presence of a subclavicular process), are completely Peristeromorphic ; and so is the whole fore limb.

4. The pelvis has resemblances both to that of the Grouse and that of the Pigeons, but has some peculiarities of its own.

5. The foot contrasts strongly with that of the Pigeons in the extreme brevity of the tarso-metatarsus and toes, and in the reduction of the hallux, but may be regarded as an exaggeration of that of the Grouse.

According to Nitzsch, the pterylosis is Peristeromorphic ; and Mr. Parker (*l. c.* p. 150) has shown that while the vocal organs are Pigeon-like, the digestive organs are Tetraonine.

Thus the *Pteroclidæ* are completely intermediate between the *Alectoromorphæ* and the *Peristeromorphæ.*[1] They cannot be included within either of these groups without destroying its definition, while they are perfectly definable in themselves. Hence, I think, the only advisable course is to make them into a group by themselves, of equal value with the other two, under the head of *Pteroclomorphæ.*

The *Hemipodidæ* differ much more from the *Alectoromorphæ*, *Pteroclomorphæ*, and *Peristeromorphæ* than these groups do from one another.

1. The number of the cervical, dorsal, and lumbar vertebræ is indeed the same; but that ankylosis which is so constant and so remarkable among the birds which have been already mentioned is absent. All the vertebræ are distinct from one another, as Mr. Parker has already noticed (*l. c.* p. 184).

2. The palatines, pterygoids, and basipterygoids are more Pluvialine, though there is a touch of the Pigeon both in these parts and in the mandible. They are very different from the corresponding bones in the *Alectoromorphæ* and *Pteroclomorphæ.* The broad flat vomer, however, is not Pluvialine, but is more Grouse-like.

3. The sternum appears to me to be, as nearly as may be, intermediate between that of the *Pteroclomorphæ* and that of the *Tinamorphæ.* If the inner notch, which is already so small in *Syrrhaptes*, were reduced to nothing, the sternum would differ from that of

[1] M. Blanchard excludes *Pterocles* from the "Gallinacés," and expresses, "without the least doubt," the opinion that this genus should be ranged among the Pigeons. "La forme de leur sternum, de leur bassin, de leurs membres antérieurs, de leur humérus notamment, ne peut laisser à cet égard la moindre incertitude" (Blanchard, *l. c.* p. 93). M. Blanchard does not mention *Hemipodius*, and is uncertain about the affinities of *Tinamus.*

L'Herminier is of opinion that the sum of the characters of the bird incline it towards the *Gallinaceæ*. He puts it, with Vieillot and Latreille, in the distinct family of the *Dysodes*, before the Pigeons and Gallinaceous birds.

M. Gervais (*l. c.* p. 72), on the contrary, denies that *Opisthocomus* has anything to do either with the Gallinaceous birds or with the Pigeons. He considers that it forms part of the great series of "passeriform birds," but is so different from the others that it ought to form a separate order in this series, near the *Scansores*, and "near the *Musophagidæ*, though its affinities with the group may have been exaggerated."

In my paper on the Classification of Birds I have described the palate of *Opisthocomus* (p. 255), and have shown that it has an Alectoromorphic tarso-metatarsus (p. 277); but I have expressed the opinion that its other peculiarities necessitate the placing of the bird in a special division of the *Schizognathæ*. At the same time I mentioned that this opinion was based upon the examination of only an incomplete skull and the bones of the feet.

M. Alphonse Milne-Edwards, noting this indication of the paucity of my materials, with a liberality and courtesy for which I gladly express myself his debtor, placed an excellent mounted skeleton and some detached bones of the Hoazin, in his collection, at my disposition; and Mr. Eyton, with no less kindly readiness, has supplied me with another mounted skeleton of the same bird.

I have thus been enabled to make a tolerably complete investigation of its osteology, the result of which has been entirely to confirm the conclusions of L'Herminier, that *Opisthocomus* resembles the Fowls and the Pigeons in almost all those respects in which it is like other birds, while in many points it is altogether peculiar, and only in one or two features resembles the *Musophagidæ*.

I find the number of the vertebræ to be 19 cervical, 5 dorsal, 3 lumbar, 4 sacral, 6 urosacral, and 4 free caudal. To these succeeds the pygostyle, the number of the vertebræ in which is not ascertainable.

In the large number of its cervical vertebræ, *Opisthocomus* is unlike any of the birds belonging to the groups which have already been discussed; *Tinamus*, however, has 18 cervicals.

The two or three last cervical vertebræ are ankylosed with one another and with the two anterior dorsals.[1]

The third dorsal is free; but the fourth and fifth are united together, and with the succeeding vertebræ to form the "sacrum," and are overlapped by the ilia.

[1] In Mr. Eyton's specimen the second dorsal appears to be free.

A straight, styliform, osseous process, compressed from side to side and continuous with a slight crest which runs for a short distance down the anterior face of the sternum, takes the place of both manubrium and hypocleidium, being continuous, on the one hand, with the sternum, and, on the other, with the furcula.

The keel of the sternum is extraordinarily small and cut away in front, the angle formed by the union of the anterior and ventral margins being situated opposite the junction of the third and last

Fig. 8.

Fig. 9.

Fig. 8, front, and Fig. 9, side view, of the sternum and shoulder girdle of *Opisthocomus cristatus.*

fourths of the length of the bone. The anterior contour is at first concave, afterwards slightly convex. The ventral edge is at first concave and expanded from side to side, but afterwards becomes slightly convex.

The sternal ribs are attached along the anterior half of the lateral contour of the sternum.

The ridge which bounds the origin of the middle pectoral muscle externally, extends from the outer end of the articular fossa for the coracoid to the summit of the inner notch, and thence a little way upon the middle xiphoid process. The surface left between this line and the attachment of the sternal ribs is extremely narrow.

The relative proportions and form of the femur and the tibia are very nearly such as are observable in the ordinary Pigeons. The meta-

FIG. 10.

FIG. 11.

FIGS. 10 and 11. Lateral and dorsal view of the pelvis of *Opisthocomus*.

tarsus is longer in proportion to the tibia than in the ordinary Pigeons, shorter than it is in *Goura*.

The tarso-metatarsus itself (fig. 12) very closely resembles that of the Pigeons, though the form of the distal articular surface

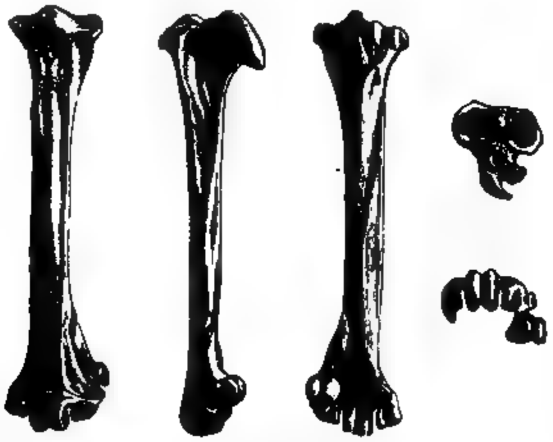


FIG. 12. The right tarso-metatarsus of *Opisthocomus*, viewed from in front, the side, and behind, with the proximal and distal ends.

of the metatarsal of the hallux is more like that of *Crax*. The tarso-metatarsus of *Corythaix* is very different.

the rostrum is formed by the præmaxillæ and nasals. But in *Opisthocomus* the hinge lies behind the lachrymals, which have completely coalesced with the nasals and form an integral part of the rostrum.

In *Tetrao urogallus* and in *Crax*, the inner margins of the lachrymals are connected almost wholly with the nasals, and their posterior margins are truncated and unite with the frontals only by a short, more or less transverse, suture. If the sutures between the nasals and præmaxillæ, on the one hand, and the frontals, on the other, were as open as this is, the rostrum would have a hinge just like that of *Opisthocomus*; and ankylosis of the lachrymals with the nasals would complete the resemblance.

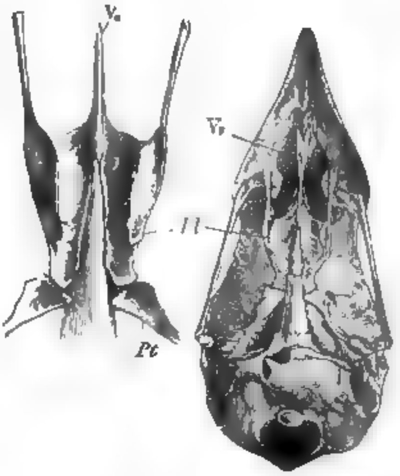


FIG. 16. The skull of *Opisthocomus cristatus*, viewed from below, with the palatine bones enlarged, from another specimen.

Vo. Vomer. *Pl.* Palatine bones.
Pt. Pterygoid.

The mandible of *Corythaix* bears a good deal of general resemblance to that of a Pigeon. In *Opisthocomus*, the mandible is like that of *Didunculus* in general form, and has the peculiar flanging out of the upper margins of the rami, which is absent in *Corythaix*, but is so characteristic of the mandible in most Pigeons.

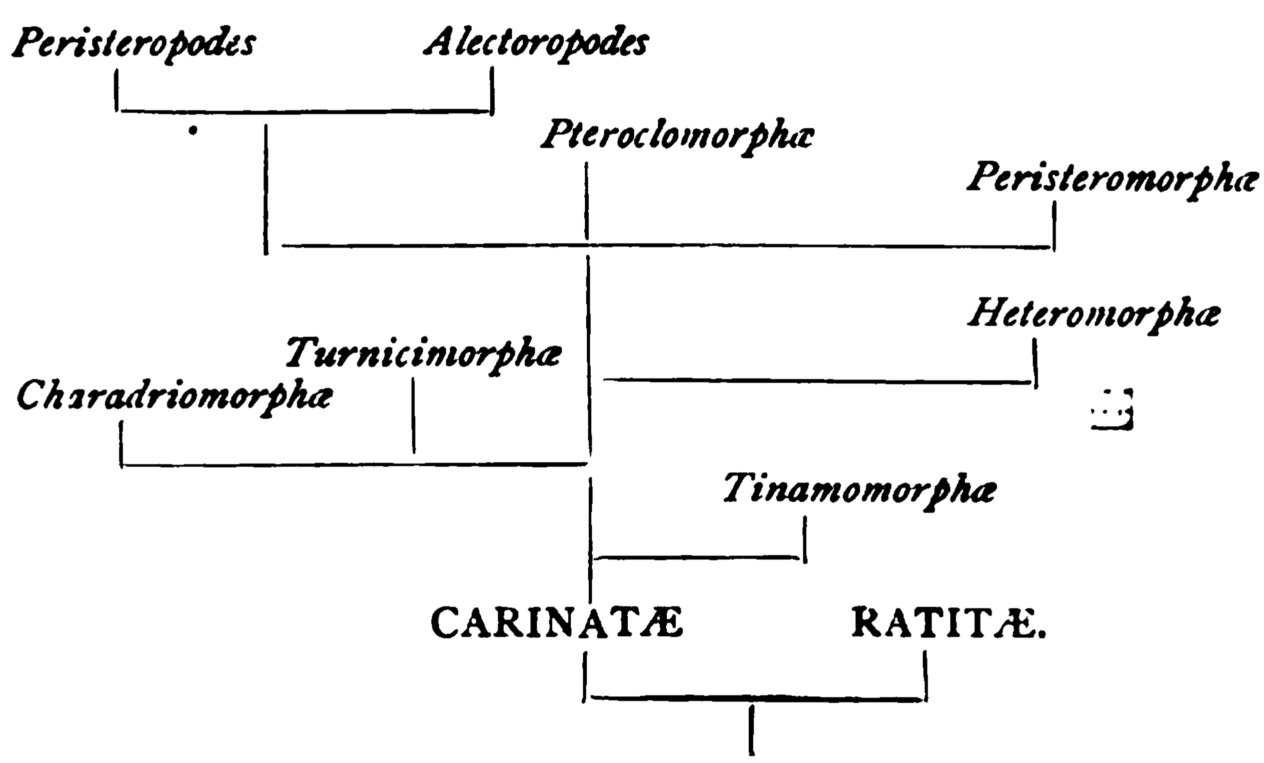
The palatine bones (fig. 16) have much resemblance to those of the Pigeons in their general form, and particularly in the development of the inner lamina. The maxillo-palatines, on the other hand, are as ill-developed as in many *Alectoropodes*; and there is not the slightest approximation to the desmognathous arrangement of *Corythaix*. The vomer, as already described, is slender and compressed from side to side, though it tends to expand in front. It resembles the vomer in the *Peristeropodes*, which is as distinctly ossified, slender, and compressed from side to side, but tapers to a point in front.

There are no basipterygoid processes—a circumstance in which *Opisthocomus* differs from all the *Alectoromorphæ* and most of the Pigeons.[1] In the antero-posterior convexity of the basitemporals and their extension outwards beneath the tympanum, *Opisthocomus* resembles the *Alectoromorphæ*.

[1] In *Goura* they are sometimes almost obsolete; and they are absent in *Didus* and *Pezophaps*.

From the point of view of the Evolution theory, all the Gallo-columbine birds must be regarded as descendants of a single primitive stock; and the relations of the different groups should be capable of representation by a genealogical tree, or *phylum* as Haeckel calls it in his remarkable "Generelle Morphologie." Such a phylum can only be put forward with confidence when a tolerably complete knowledge of the development and of the palæontological history of a group has been obtained.

But if, with our present information, I were called upon to draw out such a phylum of the Gallo-columbine birds, I should suggest some such scheme as the subjoined:—



Such a scheme implies that all the Gallo-columbine birds have had a common ancestry, and that the *Pteroclomorphæ* are the nearest representatives in the direct line of that ancestry. This, of course, no more obliges us to believe that the original Gallo-columbine bird was just like *Pterocles*, than the fact that a given nobleman is directly descended from a Norman baron compels us to think that a photograph of the one would serve for a portrait of the other.

I cannot understand the general resemblances combined with the particular differences of *Opisthocomus*, without the supposition that it is a highly modified form derived from the primitive Gallo-columbine stock.

But the resemblances between the Gallo-columbines and the *Charadriomorphæ* (or rather the *Alco-pluvialine* series) are such that, if the theory of evolution be correct, they also must have had a common stock; and I presume that the *Turnicimorphæ* may be the nearest representatives of that stock.

groups of Birds are either confined to the northern area, or are represented elsewhere by not more than one or two species—

Pteroclidæ,	*Vulturidæ,*
Otididæ,	*Upupidæ,*
Gruidæ,	*Bucerotidæ,*

while, in comparison with the southern area, it is very poor in

Ratitæ,	*Psittacomorphæ,*
Peristeromorphæ,	*Caprimulgidæ.*

With respect to Mammals, the northern area is almost coincident with the distribution of the *Insectivora,* and it is the headquarters of the *Ungulata* ; Catarrhine Apes and Lemurs are confined to it ; and it contains only two species of *Marsupialia,* and very few of *Edentata.* Among the lower *Vertebrata,* Ganoid fishes are not found outside this area.

To the southern area, on the other hand, are restricted :—

The *Ratitæ* (except *Struthio*).

The *Tinamomorphæ.*

The *Cathartidæ.*

The majority of the Pigeons, and Parrots, and all the most peculiar types of both.

The *Trochilidæ* and the *Aptenodytidæ,* with few exceptions.

Many annectent, or apparently isolated, forms of birds, such as the *Palamedeidæ, Psophidæ, Dicholophidæ, Heteromorphæ.*

Among Mammals, the *Marsupialia* are as nearly confined to and coextensive with it, as the *Insectivora* are in respect of the northern area. The Platyrhine and Arctopithecine Monkeys and the *Monotremata* are confined to it. It is the headquarters of the *Edentata,* and is very poor in *Ungulata*—so as exactly to reverse the characters of the northern area in these respects.

In a well-known and very valuable essay on the Geographical Distribution of Birds,[1] Dr. Sclater divides the surface of the globe primarily into an eastern and a western area, which he terms respectively *Palæogæa* and *Neogæa.* However, if we take into consideration not merely the minor differences on which the species and genera of Birds and Mammals are often based, but weigh the morphological value of groups, I think it becomes clear that the Nearctic province is really far more closely allied with the Palæarctic than with the Neotropical region, and that the inhabitants of the

[1] Journ. Proc. Linn. Soc. Zool. vol. ii. p. 130.

while negatively, the absence of *Insectivora*,[1] of *Viverridæ*, of all other *Ungulata* except *Cervidæ*, of all other Marsupialia, is not less remarkable.

Again, I cannot but think that the "Australian, or Eastern Palæotropical," province is certainly as distinct from the Old World proper as South America is[2], if we consider both its Birds and its Mammals, and that no fitting idea of its importance is given by making it a mere subdivision of the Old World. Exclusively confined to it are the

Dromæidæ,	*Strigopinæ*,
Dinornithidæ,	*Plictolophinæ*,
Apterygidæ,	*Trichoglossinæ*,
Didunculidæ,	*Menuridæ*.
Dididæ,	

Like Austro-Columbia it abounds in Parakeets and Pigeons; but Woodpeckers are entirely absent, and only a few Cuckoos represent the Pair-toed *Coccygomorphæ*.

Positively, this region is characterized by the abundance of Marsupials (except Opossums) over a large part of its area, by the presence of Monotremes in a small part: negatively, by the absence of almost all other terrestrial Mammals.

In fact the population of this great region (which I should prefer to call "Australasia") is so very different not only from that of Arctogæa, but from that of Austro-Columbia, that a good case might be made out for regarding it as a primary division in zoogeography, of the same value as Arctogæa and Austro-Columbia. Indeed I am not disposed to weigh lightly the claims of the New-Zealand islands to a similar distinction. This region of the world alone possesses two families of *Ratitæ* which are exclusively confined to itself. The *Alectoromorphæ* are represented only by a Quail. Again, in the absence of all *Ophidia* and *Chelonia*, and of all terrestrial *Mammalia* with the doubtful exception of a Rodent or two, New Zealand is without a parallel in lands of its size.

If this view were admitted, it would be requisite to divide the earth's surface, for the purpose of geographical zoology, into four

[1] *Solenodon* is confined to two West-Indian islands—Cuba and Haiti; *Bassaris* is but a doubtful Viverrine, and gets no further south than Mexico.

[2] "Quelles que soient du reste les destinées ultérieures du principe que je viens d'émettre relativement au mode à suivre pour la détermination des faunes spéciales, il est impossible de nier que, sous ce point de vue, l'Amérique méridionale, d'une part, la Nouvelle Hollande, d'autre part, doivent être séparées du reste du monde."—PUCHERAN, *Sur les indications que peut fournir la Zoologie, &c.* (*Revue et Magasin de Zoologie*, 1865, p. 162).

ern forms overlapping, more or less, from the isthmus to the lakes. If this portion of North America were now to be partially submerged and broken up into islands, Mexico would stand in the same relation to Austro-Columbia as Sumatra does to India; and the population of the country north of the lakes would resemble that of Northern Asia more than the fauna of New Guinea does that of Australia. The intermediate islands would correspond with the chain of the Indian archipelago.

It is a trite remark that none of the great zoogeographical provinces, however we may circumscribe them, are sharply defined from one another, if the larger groups, such as genera and families, are taken into consideration. Each province has its *characteristic groups* limited to itself; but every two are also united by *annectent groups.*

If we consider Arctogæa as having Austro-Columbia on the west, and Australasia on the east, these annectent groups will be divisible into eastern and western. Now it is a remarkable circumstance that a large proportion of these annectent groups, whether eastern or western, are restricted to the two provinces which they connect, and do not extend into the third.

Thus the following eastern annectent groups extend from Australia over a very wide extent of Arctogæa, while they are wholly wanting in Austro-Columbia:—

Hemipodidæ,	*Gruidæ,*
Otididæ,	*Meropidæ,*
Glaerolidæ,	*Coracidæ,*

among Birds; and the Frugivorous Bats among Mammalia.

Others have the converse distribution; that is to say, they exist in Austro-Columbia and over a large part of Arctogæa, but are absent in Australia:—

Psittacinæ,	*Celeomorphæ,*
Trogonidæ,	*Amphimorphæ,*

among Birds; and

Primates (except Man),	*Ungulata,*
Carnivora,	*Edentata,*

among the *Mammalia.* And it is further remarkable that, among these western annectent Mammalia, there are sundry important families, such as the *Camelidæ, Cervidæ, Tapiridæ, Ursidæ, Subursidæ,* and (with one or two exceptions) the *Melidæ* and *Mustelidæ,* which are found both in Austro-Columbia and Asiatic Arctogæa, but are absent in South Africa.

they are absent from the miocene fauna of Arctogæa, it will be necessary to suppose that these groups of birds are of sufficiently ancient origin to have been segregated, even before the miocene epoch, in Austro-Columbia and Australasia, whence they have subsequently colonised parts of Arctogæa; while, on the other hand, their presence in European miocene formations will render it possible that the colonisation has taken place the other way, and that these birds have attained their wonderful multiplicity and diversity of forms in Austro-Columbia and Australasia simply in consequence of the very favourable nature of the conditions to which they have been exposed in that country.

I confess I incline to the latter supposition. The distribution of *Psittacula*, for instance, is quite unintelligible to me upon any other supposition than that this genus existed in the miocene epoch, or earlier, in Northern Arctogæa, and has thence spread into Austro-Columbia, South Africa, India, and the Papuan islands, where it is now found.

In the ten years which have elapsed since the papers to which I have referred were read before the Society, the age of the reptiliferous sandstones of Elgin has been repeatedly discussed by some of the most eminent of English geologists, with the general result that while one half of the disputants produced excellent reasons for believing them to be of Mesozoic date, the other half adduced no less weighty arguments in favour of their Palæozoic age. And it is a curious circumstance that in this Geological Siege of Troy, Priam has been fighting the battle of the Greeks, and Nestor that of the Trojans,—Sir R. Murchison, whose general geological views would naturally incline him to assign a later date to these Elgin reptiles, having been the sturdiest champion of their Devonian age; while Sir Charles Lyell, who ought to rejoice if they could be made out Palæozoic, has as strongly fought for their belonging to the Trias. Without meaning to compare myself to Achilles, I may say that "under these circumstances" I thought it best to retire to my tents and take no part in the fray until my palæontological armoury should yield more efficient weapons. And as my excellent friend Dr. Gordon supplied me from time to time with new specimens, I lived in hope that one day or other I should be able to make an effective sally.

No such opportunity presented itself, however, until the year 1867, when a number of important facts came to light in singular coincidence, and, as I conceive, rendered the proper discussion of the question and the drawing of satisfactory conclusions somewhat easier than before.

I may premise that the original specimen of *Hyperodapedon* is in a very bad condition, the substance of the bones and teeth being extremely friable and decayed. It is nevertheless sufficiently clear that the roof of the mouth is provided with several parallel rows o teeth, that the edge of the ramus of the lower jaw is also beset with a series of close-set or even confluent teeth, and that the mandibular teeth bite between the inner and outer series of the palato-maxillary teeth. The surfaces of the teeth, however, are not sufficiently preserved to enable one to make sure of the manner in which the teeth wear.

For a number of years I have been acquainted with two specimens from the quarry opened in a Triassic sandstone at Coton-End, near Warwick—the one belonging to the Warwick Museum, and the other to the Rev. P. B. Brodie, F.G.S. Each of these is an elongated jaw-like bone, in which are set parallel rows of conical teeth; and I have often compared them with the palate of *Hyperodapedon*, but without

and consider that these overlying sandstones and limestones are of Upper Triassic age."

Shortly after these new lights upon the structure and stratigraphical position of *Hyperodapedon* had appeared, the able Director of the Geological Survey of India, Professor Oldham, who happened to be in England, drew my attention to some specimens obtained from Maledi, in Central India, and presented to this Society in 1860 by the Rev. Mr. Hislop. Among these were fragments of large jaws with teeth, which presented all the characters of *Hyperodapedon*; and during the past autumn I received from Dr. Oldham a considerable number of similar remains, associated with those of Labyrinthodonts and Crocodilian reptiles. The peculiar interest of this discovery arises not only from the sudden, enormous extension of the distributional area of *Hyperodapedon*, but still more from the circumstance that Dicynodonts have been found in the same Indian strata, and, thus, that we get a step nearer to the determination of the age of the remarkable reptiliferous formations of Southern Africa, the Triassic or Permian age of which was already highly probable.

The last fact which needs to be mentioned in this history of the gradually growing importance of the genus *Hyperodapedon* is the highly interesting and important collateral evidence as to its age obtained by Mr. Whitaker, who will presently give you an account of the precise position in the Trias of Devonshire in which a specimen of the jaw of *Hyperodapedon*, which he brought to me a few weeks ago, was obtained.

I now proceed to describe the most important remains of *Hyperodapedon* which have come into my hands; and I shall speak first of the specimen on which the genus was founded, which is the property of the Elgin Museum, and was sent to me in 1858.

The remains of this specimen are exhibited by the opposed faces of broken blocks of sandstone, some of which have been separated by splitting along the plane in which the fossil lay. On one of these blocks are the indications of seventeen vertebræ in a continuous series, though slightly disturbed from their normal position here and there. The bodies of all these vertebræ have about the same length, viz. 0·9 in. or 0·95 in. They are so much constricted in the middle as to be almost hour-glass shaped, and their terminal articular surfaces are slightly concave. In most of the vertebræ the neural arches and spines are shown indistinctly, or not at all; but the sixth in order from the anterior end of the series is tolerably complete, and exhibits a broad and not very high spine, the summit of which

is somewhat narrower than the base. This passes into the arch of the vertebra, which exhibits well-developed articular processes. The total height of the vertebra, from the lower edge of the posterior articular surface to the summit of the spine, is 1·85 in., that of the posterior articular surface of the centrum being 0·7 in.

The fourteenth vertebra of the series, from its general character and relations to the pelvis, is, without doubt, the principal sacral vertebra. The impression which it has left appears to me to have been formed by the outer face of the right sacral rib. Certainly not more than one of the three succeeding vertebræ, the two hindermost of which are represented by little more than casts of their neural canals and of the region thereabouts, can have been united with the principal sacral vertebra to form the sacrum.

On clearing away the friable remains of the original bone from the hard sandstone matrix, the latter presents casts of the external surface and of the neural canal of each vertebra, which, in some cases, are very perfect. These casts show no sign whatever of the deep pits which would correspond with well-developed transverse processes; but there is a depression at the anterior part of each body of a vertebra answering to what appears to have been a low tubercle for the attachment of a rib, as in existing lizards.

In correspondence with this structure of the vertebræ, the remains of a number of ribs, which have been laid bare by chiselling away portions of the matrix, show no trace of a division into capitulum and tuberculum at their vertebral ends. The longest of them is 4 inches in length. Like the rib of a *Monitor*, its vertebral end is somewhat expanded; and it is so curved as to be, at first, a little concave towards the dorsal aspect; in the rest of its extent it is convex in that direction.

I see no remains of true sternal ribs; but there are numerous faint transverse linear impressions of a system of dermal ossifications, which, I conceive, answers to the so-called "abdominal ribs" of a Crocodile, or to the corresponding structures in *Sphenodon*. These, however, are better shown in another slab.

To the anterior extremity of the block of sandstone which contains these vertebræ (and which I shall call No. 1) fits another, which bears the anterior cervico-dorsal vertebræ and the skull. The latter is bent round so that its axis is nearly at right angles with that of the body.

None of these anterior cervico-dorsal vertebræ can be clearly made out; but they cannot have been numerous, and I doubt whether there were altogether more than twenty, or twenty-two, presacral vertebræ.

The skull had a length, when complete, of not less than 7 inches. It is about 5 inches broad posteriorly, but anteriorly narrows to a deflexed and comparatively slender snout, the diameter of which is not more than 1 inch. It is so disposed as to turn its ventral aspect to the eye. The left ramus of the lower jaw is in place, though much mutilated. The right ramus is broken away, and shows the oral surface of the palate and maxilla, with the obscure remains of several obtusely conical teeth.

On the left side, a good deal of the dentary edge of the left ramus of the mandible is preserved, and it is seen to be shut against the upper jaw, passing on the inner side of a series of mutilated teeth, which are fixed on the maxilla. The end of the snout presents a very remarkable structure. The anterior portion of the edge of each maxilla curves upwards, so as to leave a deep notch between itself and the downwardly curved beak-like anterior termination of the snout, which appears to be formed altogether by the præmaxillæ. Into this notch the surface of the matrix indicates that curved upward processes of the mandibular rami fitted. Whether these processes, and those of the præmaxillæ which projected between them over the mandibular symphysis, ended in teeth, or not, cannot be determined, as the extremities of the premaxillary processes are broken away, and the mandibular processes are represented only by impressions. But it is very likely that such was the case, if we may judge by the analogy of some existing lizards (such as *Uromastix spinipes*), which present a very similar arrangement of the extremities of the jaws. The two præmaxillæ, however, are confluent in this lizard, while they are distinct from one another in *Hyperodapedon*.

From the dentary margin the outer surface of each maxilla inclines rapidly outwards, so that, even making allowance for partial artificial depression, the measurement from the outer margin of one orbit to the other is nearly double that between the dentary margins of opposite sides. This conformation of the upper jaw also obtains, though to a less extent, in *Uromastix*.

The orbit was large; but its form cannot be accurately determined, almost the whole of the roof of the skull being absent. There is a cast of a strong supratemporal zygomatic arch, formed in part by a prolongation backward of the jugal, and in part by a forward extension of the squamosal, as in *Uromastix*. Clear indications of a strong quadrate bone and of a pterygoid are also visible; and the remains of a long slender left cornu of the hyoidean apparatus lies parallel with the left ramus of the mandible, on the ventral face of the skull. No remains of any infratemporal zygomatic arch, such

as is found in *Chelonia*, *Crocodilia*, and *Aves*, are visible; but the existence of such a structure is very probable from the analogy of *Rhynchosaurus*.

The remains of two broad plates of bone, not less than 3½ inches in length, with concavo-convex surfaces and a curved free edge, which lie near the anterior end of block No. 1, most likely represent the coracoids. A large impression of about the same length, which must have been formed by a bone which was thin at both edges, thin and expanded at one end, and thick, with an excavated terminal surface, at the other, lies near one of the coracoids; and I take it to have been made by a scapula. What I suppose to be a cast of the corresponding bone of the other side lies upon block No. 2; and there are sundry scattered imperfect impressions of limb-bones, indicating a fore leg of no great size. The right pubis and ischium have left very distinct impressions of their dorsal surfaces at the hinder end of block No. 1. In general form these bones resemble the corresponding bones in existing lizards; and the pubis has a great prepubic process, as in the latter. But the pubis and ischium of the same side seem to have united on the inner as well as on the outer side of the obturator foramen, which appears to have been proportionally much smaller than in existing Lacertilia.

The pubis and ischium occupy a space equal in length to four vertebræ, which is a proportion very similar to that which obtains in existing Lacertilia.

A distinct impression of the right femur is left almost in its natural position. It is a nearly straight and very strong bone, which is 4·7 in. long, or equal to more than five vertebræ in length. The femur has a similar proportional size in *Monitor* and *Iguana*. Impressions of the proximal ends of the tibia and fibula are visible, in such relation to the femur as shows them to have undergone very little disturbance.

No certain indication of the character of the feet is discernible.

The general arrangement of the teeth has been described. The downwardly convex dentigerous edge of the maxilla is 2·75 in. long, and appears to have carried about eighteen (or perhaps more) teeth, of a conical form and very closely set. The outer surface of the maxilla, from the dentigerous edge to the lower boundary of the orbit is fully an inch high, and is excavated and inclined outwards with a very peculiar curvature.

The dentigerous edges of the opposite maxillæ converge towards one another at an angle of about 45°, and then become parallel as the snout narrows to its termination.

No suture can be distinguished upon the roof of the mouth, between the maxillæ and the palatine bones, though the boundary line between the two is probably indicated by the groove into which the dentigerous edge of the mandible bites. The roof of the palate is therefore formed by a broad plate of bone, which may be called palato-maxillary, as it is constituted by the conjoined maxillary and palatine. Anteriorly this plate has a width of not more than 0·35 in. internal to the groove, but it widens posteriorly to 0·7 in. Its inner edge is convex towards the middle line, roughly following the course of the dentigerous edge. For their anterior halves the two edges of the palato-maxillary bones seem to be separated by

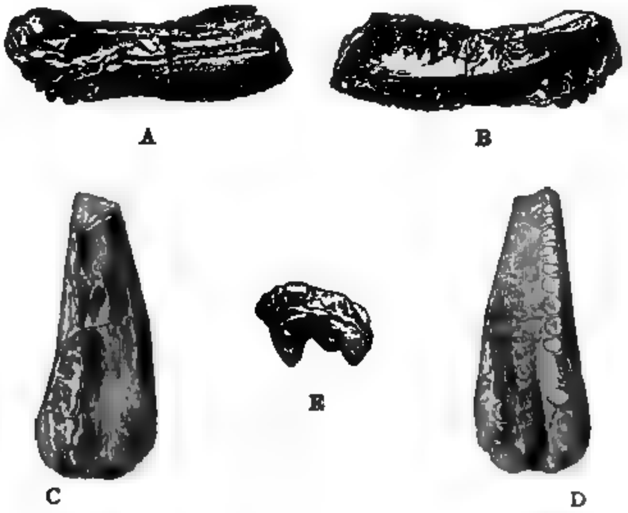


FIG. 1.—Left palato-maxillary of *Hyperodapedon*.
A. From the inside. B. From the outside. C. From above. D. From below.
E. From behind.

only a small interval; but posteriorly they diverge widely; whether the interspace was occupied by the pterygoids, or not, cannot be ascertained.

The palato-maxillary plate on the inner side of the groove bears three (or perhaps four) longitudinal series of conical teeth, the largest of which are about 0·1 in. in diameter at the base. The posterior edge of the palato-maxillary is abruptly truncated, smooth, rounded, and slightly concave backwards.

It is upon this part of the organization of *Hyperodapedon* that Dr. Lloyd's specimens throw such important light. One of them, which is smaller and more perfect than the other (fig. 1, A, B, C, D, E), exhibits

wearing down of the palato-maxillary teeth can only be explained by their attrition against the teeth of the mandible; and the sharpness of the groove in the posterior half of the palatal surface clearly shows that these mandibular teeth were themselves sharpened to a sort of knife-edge.

Dr. Lloyd's second specimen is a fragment of a larger palato-maxillary bone of the same (left) side. It is, however, smaller relatively to the original size of the bone, as some of the anterior portion is broken away, and the posterior edge, though nearly preserved, is somewhat imperfect. The transverse diameter of the nearly entire posterior end is 0·8 in.; so that this bone is about half as large again as the foregoing, and belonged to an animal probably not more than half as large as the Elgin specimen.

In this specimen the outer series of teeth is double posteriorly, two large conical teeth making their appearance on the outer side of the four which remain tolerably unworn. As before, there are two rows on the inner side of the groove; and anteriorly all the series of teeth are worn down to one flat surface with the bone which holds them.

Mr. Whitaker's specimen[1], from Devonshire, is a right palato-maxillary bone of a *Hyperodapedon* of small size, probably less than that to which Dr. Lloyd's smaller specimen belonged. It is in an imperfect condition, but shows part of a single outer series of teeth, and of two inner series, both completely worn down. The apices of four or five teeth project in two rows upon the posterior half of the inner face of this specimen.

I propose to give a full account of the Indian specimens elsewhere. At present I merely wish to observe that, for the most part, they belong to animals of a larger size than the Elgin specimen, but that I have not yet discovered any grounds for regarding them as specifically distinct. In the series sent by Dr. Oldham, there is a fragment of a ramus of a mandible which shows the scissor-edge character of the dentary margin extremely well.

With respect to the affinities of *Hyperodapedon*, there can be no doubt that it is very closely allied to the genus *Rhynchosaurus*, established by Prof. Owen upon a fossil skeleton from the Trias of Shropshire. But *Rhynchosaurus* has shown no trace of teeth in

[1] I am indebted to my friends the Rev. P. B. Brodie and Mr. Kershaw for drawing my attention to some additional examples of the Warwickshire *Hyperodapedon*. Two of them are fragmentary palato-maxillary bones. The third has very much the appearance of two crushed palato-maxillary bones, with one ramus of the mandible of a small specimen; but I have not been able to work it out fully.

to say whether it is entirely terrestrial or largely aquatic. Consider, for example, how nearly the aquatic and terrestrial *Varani* resemble one another, and how slight is the difference between that species of *Amblyrhynchus* in the Galapagos Islands which cannot be driven into the water, and that which takes to the sea habitually. All that can be said is that the Lacertilia are so predominantly terrestrial a group, that a member of the group is to be presumed terrestrial, or at any rate fluviatile, unless evidence appears to the contrary. True there is no evidence to the contrary in the case of *Hyperodapedon*; but, on the other hand, all that we know of its contemporaries and compatriots, *Stagonolepis* and *Telerpeton*, leads to the belief that they were terrestrial or semiaquatic. *Telerpeton*, I have little doubt, was altogether terrestrial. *Sphenodon*, the existing ally of *Hyperodapedon*, is a sluggish animal, which lives, in part, at any rate, on insects and small birds, and is said to frequent burrows in the sand near the sea-shore. The fact that no marine remains have ever been found in the deposits which contain *Hyperodapedon* remains is negative evidence which leads in the same direction; and it is strongly confirmed by the association of Labyrinthodonts with *Hyperodapedon* in Warwickshire and in India,—Labyrinthodonts, like all other amphibia, being confined to the land and fresh water.

The question of the terrestrial habit of *Hyperodapedon* assumes a great importance when the wide distribution of the genus is taken into consideration. It has now been discovered in the North of Scotland, in the centre of England, and in central India; and if it were, as I doubt not it was, a terrestrial or semiterrestrial animal, that alone indicates the existence of a very extended mass of dry land in the Northern hemisphere during the period in which it lived. And the proof of the existence of continental land in the Northern hemisphere acquires increased interest when we consider the evidence which shows what period this was.

The cardinal fact in that evidence is the occurrence of *Hyperodapedon* in the Coton-End Quarry in Warwickshire, as proved by Dr. Lloyd's specimen. It has never been doubted, I believe, that the Sandstone in which this quarry is excavated is of Triassic age. It has yielded Labyrinthodonts and Thecodont Saurians; and its stratigraphical position is such that the only question which can possibly arise is, whether it is Triassic or Permian.

As next in order of value, I take the discovery of *Hyperodapedon* in the Devonshire Sandstone, the determination of which as Trias rests, as Mr. Whitaker will inform you, upon independent grounds.

In England and Scotland, *Hyperodapedon* is found with Labyrinthodonts and Thecodont Reptilia of such distinctly Crocodiliform type as *Stagonolepis*, but no *Dicynodon* has been found.

In Würtemberg, Labyrinthodonts and Thecodont Reptilia, some of them, like *Belodon*, eminently Crocodilian, are associated together, probably with Dinosauria; but neither *Hyperodapedon* nor *Dicynodon* have yet been discovered.

All these four faunæ are connected by reptilian genera, which are respectively common to two of them: thus the British and the Indian by *Hyperodapedon*; the Indian and the African, by *Dicynodon*; the British and the German by *Labyrinthodon* (which according to Von Meyer occurs in Germany). The Labyrinthodonts and Crocodiliform reptiles are common to all four.

As the age of the beds in question is determined stratigraphically in Britain and in Germany to be Triassic, it may seem over-refinement to hesitate in declaring the African and Indian formations to belong to the same period; but I confess that the arguments I have mentioned lead me greatly to prefer some more general term, which should indicate a wider chronological range for the duration of the terrestrial fauna in question. The term *Poikilitic*, originally used by Conybeare to designate the Newer Red Sandstones of this country, seems to me to be very fit for this purpose: and in speaking of the Poikilitic period, I should like to make its earlier and later boundaries as hazy as possible, and to apply it exclusively to terrestrial conditions and to land and freshwater faunæ, without prejudice to the limits in time of the marine conditions known as Permian and Triassic.

It does not appear to me that there is any necessary relation between the fauna of a given land and that of the seas of its shores. The land faunæ of Britain and of Japan are wonderfully similar; their marine faunæ are in many ways different. Identical marine shells are collected on the Mozambique coast and in the easternmost islands of the Pacific; while the faunæ of the lands which lie within the same range of longitude are extraordinarily different. What now happens geographically to provinces in space, is good evidence as to what, in former times, may have happened to provinces in time; and an essentially identical land fauna may have been contemporary with several successive marine faunæ.

At present, our knowledge of the terrestrial faunæ of past epochs is so slight, that no practical difficulty arises from using, as we do sea-reckoning for land-time; but I think it highly probable that, sooner or later, the inhabitants of the land will be found to have a

And why are the freshwater fishes also allied to, and in one case specifically identical with those of South America[1], instead of resembling Triassic Ganoids?

I cannot give a direct answer to these questions, but I can show that analogous difficulties exist in cases where there can be no sort of doubt as to the origin of a fauna. Thus there can be no doubt that the fauna of Ireland is derived from the same source as that of Europe; but just as New Zealand is devoid of the class Mammalia, so is, or was, Ireland devoid of the class Reptilia; again, there is no indigenous British Ganoid or Siluroid freshwater fish, though both occur in the rivers of Central and Eastern Europe.

May it not be possible that causes similar to those which have shut out whole groups of Vertebrata of the European fauna of the present epoch from the British region, operated upon New Zealand in the Poikilitic period and caused its fauna to represent only a fraction of that of neighbouring lands? Or may it not be possible that causes such as those which determined the extinction of the indigenous horse, *Macrauchenia*, *Toxodon*, *Glyptodon*, &c. of South America, while they left multitudes of other genera alive, have similarly weeded down the fauna of New Zealand, and that investigations in the caves and superficial deposits of that country will yield forms which now no longer exist there?

I mention these possibilities simply for the purpose of showing how much greater value attaches to the positive similarities between the New-Zealand Fauna and that of the Trias than to their negative differences.

Finally, I may remark upon the complete modification of former ideas respecting the supposed poverty of life during the Poikilitic epoch which has been effected by the discoveries of late years.

It is now clear that all the five classes of the Vertebrata, viz., Mammalia, Aves, Reptilia, Amphibia, and Pisces, were represented at this epoch. The mammals were apparently Marsupials, not Monotremes. Of the birds nothing is known. Of reptiles, we have Dinosauria, Crocodilia, Dicynodonts, Lacertilia of several forms, Plesiosauria, and perhaps Ichthyosauria; of Amphibia, a great number of Labyrinthodonts, some of which were of enormous size; of fishes, Ganoids and Elasmobranchs.

So long as mammals and birds were known to occur no further back than the older Tertiaries or the middle Mesozoic rocks, it might be legitimate to imagine that they came into existence somewhere

[1] I state these remarkable distributional facts on the high authority of Dr. Günther, F.R.S.

XXI

ON A NEW LABYRINTHODONT FROM BRADFORD

The Quarterly Journal of the Geological Society of London, vol. xxv., 1869, *pp.* 309-311. (*Read May 26th*, 1869.)

PLATE XI. [PLATE 26.]

THE specimen which Mr. Miall has been so good as to send for my examination is without doubt a Labyrinthodont Amphibian. This is proved by the character of the vertebræ, of the ribs, and of the ventral armour. But the state of the fossil is such that it is not easy to discover points in which it can be strictly compared with those forms of Labyrinthodonts which are already known.

For example, nothing remains of the skull but some fragments of the upper and lower jaws. The piece of bone which represents the right upper jaw is 7 inches long, and has, like a fragment of the left upper jaw which lies below it, a pitted sculpture. A part of the right ramus of the mandible, with its symphysial end entire, is about 6 inches long, and about half an inch deep at the symphysis. Both upper and lower jaws bear close-set, even-sized teeth, nearly circular in section and somewhat recurved at their apices, which are rather obtusely pointed. Parallel longitudinal folds are indicated upon the basal halves of some of these teeth, the largest of which is not more than 0·5 in. long, by 0·15 in. thick at the base (Pl. XI. [Plate 26] fig. 1). An impression of a conical acutely pointed tooth, much larger than any of these (seeing that it must have had a length of nearly an inch when it was entire), is seen upon the matrix, 2 inches below the ramus of the mandible.

These features of the fossil prove sufficiently that it is not *Anthracosaurus*, but leave open the question of its identity with other Coal-measure Labyrinthodonts, and especially with *Pholidogaster*, the only fragments of the teeth which are preserved, in the latter genus, being not unlike those of the present specimen.


ETRAONIDÆ
MELEAGRIDÆ
ORTHERN LIMIT OF
THE CRACIDÆ
CRACIDÆ

RPHÆ.

On the whole, I think it will be best to recognize it as a new generic and specific form, for which I propose the name of *Pholiderpeton scutigerum.*

Note on the LOCALITY *of the* FOSSIL *above described.*

By LOUIS C. MIALL, Esq.

[Abridged.]

Fragments of the fossil above described were found last summer in the roof of the Black-bed or Royd's Coal, at Toftshaw, near Bradford. Much difficulty was experienced in extricating the remains uninjured, for the Coal beneath had yet to be worked. The greater portion was ultimately removed in a fair state of preservation, owing to the persevering attention of William Firth, a miner whose zeal was stimulated by some knowledge of geology and in particular of coal fossils.

The shale which forms the roof of the Black-Bed Coal has long been known to collectors as a repository of interesting and well-preserved fish-remains.

The Black-Bed Coal is in the middle division of the Yorkshire Coal-field, lying about 40 yards above the Better-Bed Coal, and separated by about 220 yards from the Halifax Coals, which are the lowest workable seams. The exact horizon of important fossils is, perhaps, worth noting, though within the Coal-measures no true vertical limits of species are known to exist.

Judging from a cursory survey of several public and private collections, I am inclined to think that the remains of various interesting carboniferous Batrachians are still unrecognized as such, and taken by their possessors for parts of fishes. When we are in a position to make a correct estimate, it will probably be found that the Batrachia of the Coal measures are not only specifically numerous but individually abundant.

EXPLANATION OF PLATE XI. [PLATE 26.]

(All the figures are of the natural size.)

Fig. 1. Part of the upper jaw with teeth of *Pholiderpeton scutigerum.*

Figs. 2, 3, 4, 5. Scutes from various parts of the body.

Fig. 6. Front view, and Fig. 7, side view, of a detached vertebra: *a*, remains of the transverse process; *b*, the præzygapophyses; *c*, the posterior face of the centrum, the inferior moiety of which is broken away.

XXII

ON THE UPPER JAW OF MEGALOSAURUS

The Quarterly Journal of the Geological Society of London, vol. xxv., 1869. pp. 311–314. (Read May 26th, 1869.)

PLATE XII. [PLATE 27.]

As all who have paid attention to the *Dinosauria* are aware, our knowledge of the structure of the skull in these extinct reptiles is very defective. This is particularly true of *Megalosaurus*, of which up to the present time, only a portion of the lower jaw has been known. I am therefore very glad to be enabled, by the kindness of Mr. Abbay, the possessor of the magnificent left upper jaw of *Megalosaurus* now exhibited, to make a definite addition to our means of reconstructing that monstrous Saurian.

The jaw (Plate XII. [Plate 27]) is 17·75 inches in length. At its anterior end it measures 4·3 inches in a direction perpendicular to its length. For about an inch and a half from the anterior edge (*a*), which is entire and shows the natural face of this part of the bone, the upper, or nasal, margin is nearly parallel with the lower, or alveolar, margin; but further back the bone was evidently produced into a great ascending process (*b*), which divided the nasal from the orbital region. The base of this process is fully four and a half inches long. Its anterior margin slopes rapidly backwards and upwards, and seems to have been nearly straight; while the posterior margin is concave backwards and presents a natural edge, which formed the front boundary of the orbit. The distance in a vertical line from the alveolar margin to the broken upper extremity of the ascending process is 6·75 inches. Behind the ascending process, the vertical diameter of the jaw diminishes, until, at 10 inches from its anterior end, its vertical diameter does not exceed 2·6 in. Behind this point the jaw seems to diminish to a mere bar of bone, not an inch deep at its posterior extremity. But the

Quart. Journ. Geol. Soc. Vol. XXV. Pl. XII.

G.H.Ford, del.

A.Hammond. Lith.

UPPER JAW OF MEGALOSAURUS

impression on the lower part of the matrix which occupies the cavity of the orbit shows that the natural edge of the jaw in this region has been somewhat broken away, and that, if it were entire, the depth of the jaw, at 12 inches from the anterior end, would be 2·1 inches, instead of only 1·7 inch as it appears to be. At this place, namely 12 inches from the anterior end, the jaw is transversely fractured; and though the slender prolongation adjusts quite accurately to the broken surface and evidently fitted on, it has, as evidently, lost a good deal along its upper or orbital margin.

Again, the general character of the slender posterior termination of the jaw (*c*) is such that one would be inclined to think it could not have been directly connected with any other bone; but the part is so much injured that it is not safe to draw any very positive conclusions about the matter. The jaw is traversed by a vertical fracture 2·4 inches from its anterior end. The fracture passes from the alveolar margin to the nasal margin at the commencement of the ascending process. I was at first disposed to think that the fracture coincided with a suture between the præmaxilla and the maxilla; but closer examination does not confirm this supposition, the fracture appearing to be altogether artificial. Hence it would appear either that the præmaxilla and maxilla were so completely ankylosed that all trace of their primitive separation is lost, or that the præmaxilla has become detached from the maxilla, or that the jaw is simply the præmaxilla—a possibility which must not be lost sight of in view of the resemblances between *Dinosauria* and Birds.

The teeth which remain in their places in the jaw, and are visible from the outer side, are six in number. Five of these, the first, second, third, fourth and fifth, appear to be completely in place; the third is emerging. On the inner face of the jaw the crown of a sixth tooth, in course of development, lies on the inner side of the base of the fifth.

The first tooth is laid bare by the breaking away of the substance of the jaw through its whole length. It measures 6·4 inches in length, 2·6 inches of this length being occupied by the crown, the rest by the fang of the tooth. The fang is an inch wide where it passes beyond the alveolar margin of the jaw. It is nearly straight, and seems to have been slightly compressed from side to side. The crown is laterally compressed, slightly curved, and tapers to a point. Its anterior longitudinal contour is convex; the posterior is concave, and formed by a ridge with a serrated free margin. I observed traces of the former contour of a large tooth in the middle of the wide interval between the first and the second tooth.

The second tooth is the biggest of all, and projects for nearly three

XXIII

THE ANNIVERSARY ADDRESS OF THE PRESIDENT

The Quarterly Journal of the Geological Society of London, vol. xxv., 1869, *pp. xxviii.–liii.* (*Delivered February 19th*, 1869.)

I REGRET to have to announce that the list of Fellows of this Society deceased since the last Anniversary contains many distinguished names. In most cases their distinction has been won in fields not purely geological; but in the Rev. S. W. KING, Geology, and especially Quaternary Geology, has lost a zealous and able cultivator, and the Society a Member of great accomplishments and very versatile abilities. Continued illness prevented him from publishing the results of his labours; but his fossils, collected with the utmost care and accompanied by valuable notes, have enabled Dr. Falconer and Professor Heer to give an adequate account of the animals which lived upon the preglacial continent and of the vegetation which clothed its surface [1].

SAMUEL WILLIAM KING, born September 20, 1821, was the eldest son of the late Rev. William Hutchinson King, formerly Vicar of Nuneaton. At an early age he showed a taste for scientific studies. While a mere boy, from fourteen to sixteen years old, he kept a journal in which astronomical observations and dissections of insects were noted down. Some of his papers were published at the time in the 'Zoologist.' As he grew older he turned his attention also to Archæology and Architecture. He entered at St. Catherine's College, Cambridge, and took the degree of B.A. in 1844, and that of M.A. in 1847. In 1849 he married Emma, daughter of the late John Fort, Esq., M.P., and in 1851 was presented to the Rectory of Saxlingham, Norfolk, where he devoted himself with unflagging

[1] See Lyell, 'Antiquity of Man,' pp. 214–217.

tation, and a large number of Dr. Falconer's type-specimens of Mammals, should be presented to some museum where it might be used for the advancement of the science he loved so well. Accordingly it has found a resting-place in the Museum of Practical Geology in Jermyn Street.

Quaternary Geology has suffered additional losses among our Foreign Members in M. Boucher de Perthes and M. Morlot, whose names will be always honourably associated with that revival of scientific inquiry into the antiquity of man of which this generation has been witness.

M. JACQUES BOUCHER DE CRÉVECŒUR DE PERTHES, who died in August last, was born in the year 1789, at the commencement of that great era of change which divides modern France from old France. He could hardly recollect the Terror; but the Directory, the Consulate, the Empire, the Restoration, the second Republic, and the second Empire, all had swept before him.

Possessed of an independent fortune, of considerable and varied powers and wide sympathies, M. Boucher de Perthes early resigned an official appointment in order to devote the long remainder of a healthy and vigorous life to travel, to literature, to archæology, and to science. His industry was exemplary, his enthusiasm boundless, his imagination fully equal to all demands made upon it. Hence it is no wonder that his fertile pen poured forth travels, political speculations, and a very readable novel—that he occupied himself with the past of man, and even with the future of woman. But he is most widely known by the great stimulus which his 'Antiquités Celtiques et Antédiluviennes,' published in 1849, gave to the study of the evidence of the antiquity of man which is afforded by the worked implements found imbedded in the same deposits with extinct animals.

The geologists of his own country treated M. Boucher de Perthes's work with indifference and neglect; and no doubt popular historians of science, judging after the event, will hereafter visit them with reprobation for their blindness and their prejudices. But just and critical students of the 'Antiquités' will, I think, be able completely to comprehend, and largely to justify, the course taken by the French geologists. Columbus discovered the new world; and great is his fame for that achievement, history, like some other great powers, always paying upon results: but those who will look carefully into the matter will find that most of his reasons for believing in the

The discovery upon which M. Morlot laid most weight, is that of the "Cône de la Tinière," which he converted into a chronometer for measuring the duration of the different prehistoric epochs. M. Morlot's last production is a great work upon Mecklembourg.

JAMES DAVID FORBES, late Principal of the University of St. Andrews, in Scotland, was born in Edinburgh on the 28th of April, 1809. His mother died shortly after his birth, of consumption; and the boy's delicacy was such, that his father, Mr. William Forbes, of Pitsligo, thought it well to discourage rather than to stimulate his love for knowledge, mathematical studies being especially forbidden.

But nature was stronger than paternal solicitude; and natural genius made such good use of all available opportunities for study that in 1833, at the early age of 24, Mr. Forbes was appointed Professor of Natural Philosophy in the University of Edinburgh, an office the duties of which he performed with great distinction for twenty-six years, though in the latter part of that period impeded by failing health. In 1859 Professor Forbes was appointed Principal of the United Colleges of St. Salvador and St. Leonard in the University of St. Andrews, and held these offices until his lamented death on the 31st of December, 1868.

Principal Forbes attained high distinction as an original investigator in several branches of physics, while, to the general public, he was widely known and deservedly famed as the writer who had brought the grand and profoundly interesting aspects of the Alpine world before their minds with a power and distinctness which no one since the days of Saussure had approached, when the 'Travels in the Alps' were published.

My friend and colleague Mr. Geikie, F.R.S., has given so admirable an account of Principal Forbes's relation to geological science, that I venture to reproduce what he has said on this occasion:—

Principal Forbes was born in Edinburgh just twelve years after the death of the great Hutton, only seven years after the publication of the 'Illustrations of the Huttonian Theory;' and he was already a boy of ten when Playfair died. Many of his friends had been personally acquainted with these philosophers; and the memory of the fierce Plutonian and Neptunian war was still fresh in their minds when he began to give himself to scientific pursuits. These early influences are traceable all through his life. He was profoundly impressed with the originality and truth of the views propounded by Hutton and illustrated by Playfair. He speaks with enthusiasm of the "precious lessons" which one of his friends had drawn from

related to the forces which work upon the surface of the earth and effect geological changes had a special charm for him. It was this tendency which led him to wander with more than a tourist's curiosity among the glaciers of Switzerland, which first suggested to him the idea of working out by accurate observation the real cause of glacier-motion, still, in his opinion, undiscovered, and which brought him back year after year to these great mountains, where he toiled with a devotion that told at last upon his physical frame. He was the first to determine by careful measurements the amount and variations of glacier-motion. Comparing that motion to the flow of a river, he propounded the theory that "a glacier is an imperfect fluid or a viscous body, which is urged down slopes of a certain inclination by the mutual pressure of its parts." The observations and journeys which led him to this deduction are detailed in his 'Travels in the Alps,' a work in which, as in the 'Voyages dans les Alpes' of De Saussure, which he took as his model, description of scenery and narrative of adventure are happily blended with scientific observation and reasoning. The vexed question of the mechanical cause of the motion of glaciers is hardly a geological problem. I would rather refer to the abundant materials collected by Forbes in this work for the elucidation of the geological functions of glaciers. The existing operations of the ice, in scoring and polishing rocks, in transporting huge blocks of stone, and in depositing vast mounds of rubbish, are illustrated by him from many an Alpine valley. Recalling the original observations of Playfair, he points out how clear is the evidence for the former wide extension of the glaciers of Switzerland. In short, his eye seems ever to have been upon the watch for every phenomenon bearing upon the mutations of the existing surface of the land.

The lessons which he had thus laboriously learned among the living ice-rivers of the Alps, bore fruit when he came again to wander among the more mountainous regions of his own country. In the year 1840 Agassiz had made the startling announcement that the British islands had once been deeply buried under a vast mantle of snow and ice, and that the traces of its seaward motion were yet fresh and clear upon the sides of many valleys among the uplands. Following up the observations of the Swiss naturalist, Buckland and Lyell had pointed out the former existence of glaciers in the Highlands and other parts of the country. When, however, we look back upon the early discussion of this subject, we are forced to admit that conclusions were often based upon very hasty and imperfect observations. In particular, glacier moraines were often recognized in

more especially on the analogies between the volcanic rocks of that district and the trappean masses of his own country. Throughout his narratives of foreign travel, also, we everywhere meet with indications that, though busied with what had become his own more special branch of the science, he remained no indifferent observer of the rocks among which his journeys led him. He retained his fondness for mineralogy to the end. When I last saw him at St. Andrews he showed me a collection of veined agates which he had accumulated in the course of years, and with which he used often to beguile a little leisure in trying to speculate upon the manner in which the concentric siliceous coatings might have been formed.

In concluding this sketch of the late Principal's geological labours, I must not forget that some of his researches, though in themselves dealing with more or less distinctively physical questions, had often important geological bearings. Such were some of his meteorological investigations, and his carefully conducted experiments upon the temperature of the earth at different depths and in different soils near Edinburgh. These experiments were, I believe, the first made in this country, with any degree of precision, to determine the rate at which the temperature of the surface is conducted downwards, and the variations due to differences in the nature of the material through which the heat is transmitted.

Sir DAVID BREWSTER was born at Jedburgh in December, 1781, and had thus attained the advanced age of more than eighty-six years, when he died in February of last year. During this long life his scientific activity was incessant, and the stream of his original papers, some 300 in number, flowed on without a check.

Nor did this singular fertility by any means exhaust Sir David Brewster's energies. He wrote in the Reviews frequently and well; he edited the 'Edinburgh Encyclopædia,' and shared in editing the 'Edinburgh Philosophical Journal,' the 'Edinburgh Journal of Science,' and the 'Philosophical Magazine.' He founded the Scottish Society of Arts, and helped to found the British Association; he was Principal of St. Andrews, and afterwards of Edinburgh University; he was long Secretary of the Royal Society of Edinburgh, and he died the President of that learned body.

With all these occupations Sir David found time to invent one of the prettiest of toys, the Kaleidoscope; to write one of the most charming of popular scientific treatises, the 'Letters on Natural Magic;' and to enter into a considerable number of controversies, in which he displayed such a capacity for the outpouring of copious

sary basis of information, lead the way to further researches. In 1863 Dr. Porter contributed a paper to this Society "On the Occurrence of Large Quantities of Fossil Wood in the Oxford Clay, near Peterborough;" he likewise, at different times, communicated various memoirs on professional subjects to the Medical Society.

It must ever be a subject of regret to geologists, as it was to the last to himself, that during the latter years of his life our esteemed associate was prevented by his feeble state of health, combined with his numerous professional and other engagements, from devoting much time to scientific pursuits. His death, which took place at the early age of thirty-six, was hastened by an accident, a fall from his horse, resulting in paralysis, which terminated fatally, August 11, 1868.

Dr. Porter was an assiduous labourer for the benefit of his native town, in which the well-known excellences of his character gained for him universal respect and good-will. His brilliant and agreeable qualities were never more conspicuous than when he played the part of a host; and no one could be better qualified for the authorship of the half-playful, half-serious little work, 'Cups and their Customs,' which was written in 1863, in conjunction with another Fellow of this Society, also deceased, Mr. George E. Roberts. The results of the geological labours of Dr. Porter are not to be estimated by his published writings alone; his extensive and valuable collection was always open to investigators of the geology of the district; and all who availed themselves of this privilege will remember with sadness his modesty and zeal not less than his geniality and hospitality.

The Rev. JOSEPH G. CUMMING, M.A., F.G.S., Vicar of St. John's, Bethnal Green, was the son of the late Joseph Nottrall Cumming, Esq., of Matlock, where he was born on the 15th February, 1812. Mr. Cumming was educated at Oakham Grammar School; and an old Oakham school-fellow has written of him:—"He was the very opposite of 'a pickle.' I do not think I ever saw such a grave earnest boy, cheerful, indeed, and eminently good-natured. He was, perhaps, about 14 years old when I first knew him, and we became close companions for at least two years afterwards, when I quitted the school. I do not remember that I ever saw him with a cricket-bat or fishing-rod; but he was very fond of talking of the wonders of Derbyshire, and presented me with some fossils. He was fond of wrestling, and we frequently walked to a quiet field some half mile from the town, and tugged at each other's collars for hours on pretty equal terms."

Mr. Cumming gained exhibitions at Oakham, and proceeded to

able and interesting essay, by an eminent natural Philosopher, rose into such prominence before my mind that they eclipsed everything else.

It surely is a matter of paramount importance for the British geologists (some of them very popular geologists too) here in solemn annual session assembled, to inquire whether the severe judgment thus passed upon them by so high an authority as Sir William Thomson is one to which they must plead guilty *sans phrase*, or whether they are prepared to say "not guilty," and appeal for a reversal of the sentence to that higher court of educated scientific opinion to which we are all amenable.

As your attorney-general for the time being, I thought I could not do better than get up the case with a view of advising you. It is true that the charges brought forward by the other side involve the consideration of matters quite foreign to the pursuits with which I am ordinarily occupied; but in that respect I am only in the position which is, nine times out of ten, occupied by counsel, who nevertheless contrive to gain their causes, mainly by force of mother-wit and common sense, aided by some training in other intellectual exercises.

Nerved by such precedents, I proceed to put my pleading before you.

And the first question with which I propose to deal is, What is it to which Sir W. Thomson refers when he speaks of "geological speculation" and "British popular geology"?

I find three more or less contradictory systems of geological thought, each of which might fairly enough claim these appellations standing side by side in Britain. I shall call one of them CATASTROPHISM, another UNIFORMITARIANISM, the third EVOLUTIONISM; and I shall try briefly to sketch the characters of each, that you may say whether the classification is or is not exhaustive.

By CATASTROPHISM I mean any form of geological speculation which, in order to account for the phenomena of geology, supposes the operation of forces different in their nature, or immeasurably different in power, from those which we at present see in action in the universe.

The Mosaic cosmogony is, in this sense, catastrophic, because it assumes the operation of extra-natural power. The doctrine of violent upheavals, *débâcles*, and cataclysms in general is catastrophic, so far as it assumes that these were brought about by causes which have now no parallel. There was a time when catastrophism might pre-eminently have claimed the title of "British popular geo-

at the bottom of the sea, and afterwards produced, as land, along with masses of melted substances, by the operation of mineral causes."[1]

But other influences were at work upon Hutton beside those of a mind logical by nature, and scientific by sound training; and the peculiar turn which his speculations took seems to me to be unintelligible unless these be taken into account. The arguments of the French astronomers and mathematicians, which, at the end of the last century, were held to demonstrate the existence of a compensating arrangement among the celestial bodies, whereby all perturbations eventually reduced themselves to oscillations on each side of a mean position, and the stability of the solar system was secured, had evidently taken strong hold of Hutton's mind.

In those oddly constructed periods which seem to have prejudiced many persons against reading his works, but which are full of that peculiar, if unattractive, eloquence which flows from mastery of the subject, Hutton says:—

"We have now got to the end of our reasoning; we have no data further to conclude immediately from that which actually is. But we have got enough; we have the satisfaction to find, that in nature there is wisdom, system, and consistency. For having, in the natural history of this earth, seen a succession of worlds, we may from this conclude that there is a system in nature; in like manner as from seeing revolutions of the planets, it is concluded that there is a system by which they are intended to continue those revolutions. But if the succession of worlds is established in the system of nature, it is in vain to look for anything higher in the origin of the earth. The result, therefore, of this physical inquiry is, that we find no vestige of a beginning,—no prospect of an end."[2]

Yet another influence worked strongly upon Hutton. Like most philosophers of his age, he coquetted with those final causes which have been named barren virgins, but which might be more fitly termed the *hetairæ* of philosophy, so constantly have they led men astray. The final cause of the existence of the world is, for Hutton, the production of life and intelligence.

"We have now considered the globe of this earth as a machine constructed upon chemical as well as mechanical principles, by which its different parts are all adapted, in form, in quality, and in quantity, to a certain end; an end attained with certainty or success; and an end from which we may perceive wisdom, in contemplating the means employed.

[1] 'The Theory of the Earth, p. 371.

[2] Ib. p 200.

title than catastrophism to call itself the geological speculation of Britain, or, if you will, British popular geology. For it is eminently a British doctrine, and has even now made comparatively little progress on the continent of Europe. Nevertheless it seems to me to be open to serious criticism upon one of its aspects.

I have shown how unjust was the insinuation that Hutton denied a beginning to the world. But it would not be unjust to say that he persistently, in practice, shut his eyes to the existence of that prior and different state of things which in theory he admitted; and in this aversion to look beyond the veil of stratified rocks Lyell follows him.

Hutton and Lyell alike agree in their indisposition to carry their speculations a step beyond the period recorded in the most ancient strata now open to observation in the crust of the earth. This is, for Hutton, "the point in which we cannot see any farther;" while Lyell tells us,—

"The astronomer may find good reasons for ascribing the earth's form to the original fluidity of the mass in times long antecedent to the first introduction of living beings into the planet; but the geologist must be content to regard the earliest monuments which it is his task to interpret, as belonging to a period when the crust had already acquired great solidity and thickness, probably as great as it now possesses, and when volcanic rocks, not essentially differing from those now produced, were formed from time to time, the intensity of volcanic heat being neither greater nor less than it is now." [1]

And again, "As geologists, we learn that it is not only the present condition of the globe which has been suited to the accommodation of myriads of living creatures, but that many former states also have been adapted to the organization and habits of prior races of beings. The disposition of the seas, continents and islands, and the climates have varied; the species likewise have been changed; and yet they have all been so modelled, on types analogous to those of existing plants and animals, as to indicate, throughout, a perfect harmony of design and unity of purpose. To assume that the evidence of the beginning, or end, of so vast a scheme lies within the reach of our philosophical inquiries, or even of our speculations, appears to be inconsistent with a just estimate of the relations which subsist between the finite powers of man and the attributes of an infinite and eternal Being." [2]

The limitations implied in these passages appear to me to constitute the weakness and the logical defect of uniformitarianism. No

[1] Principles of Geology, vol. ii. p. 211. [2] Ib. p. 613.

has a position in space and time, which is its DISTRIBUTION. All these form the body of ascertainable facts which constitute the *status quo* of the living creature. But these facts have their causes; and the ascertainment of these causes is the doctrine of ÆTIOLOGY.

If we consider what is knowable about the earth, we shall find that such earth-knowledge—if I may so translate the word geology—falls into the same categories.

What is termed stratigraphical geology is neither more nor less than the anatomy of the earth; and the history of the succession of the formations is the history of a succession of such anatomies, or corresponds with development, as distinct from generation.

The internal heat of the earth, the elevation and depression of its crust, its belchings forth of vapours, ashes, and lava are its activities in as strict a sense as are warmth and the movements and products of respiration the activities of an animal. The phenomena of the seasons, of the trade winds, of the Gulf-stream are as much the results of the reaction between these inner activities and outward forces, as are the budding of the leaves in spring and their falling in autumn the effects of the interaction between the organization of a plant and the solar light and heat. And as the study of the activities of the living being is called its physiology, so are these phenomena the subject-matter of an analogous telluric physiology, to which we sometimes give the name of meteorology, sometimes that of physical geography, sometimes that of geology. Again, the earth has a place in space and in time, and relations to other bodies in both these respects, which constitute its distribution. This subject is usually left to the astronomer; but a knowledge of its broad outlines seems to me to be an essential constituent of the stock of geological ideas.

All that can be ascertained concerning the structure, succession of conditions, actions, and position in space, of the earth is the matter of fact of its natural history. But, as in biology, there remains the matter of reasoning from these facts to their causes, which is just as much science as the other, and indeed more; and this constitutes geological ætiology.

Having regard to this general scheme of geological knowledge and thought, it is obvious that geological speculation may be, so to speak, anatomical and developmental speculation, so far as it relates to points of stratigraphical arrangement which are out of reach of direct observation; or it may be physiological speculation, so far as it relates to undetermined problems relative to the activities of the earth; or it may be distributional speculation, if it deals with modi-

satellites, for the general agreement in the direction of rotation among the celestial bodies, for Saturn's ring, and for the zodiacal light. He finds in each system of worlds indications that the attractive force of the central mass will eventually destroy its organization by concentrating upon itself the matter of the whole system ; but, as the result of this concentration, he argues for the development of an amount of heat which will dissipate the mass once more into a molecular chaos such as that in which it began.

Kant pictures to himself the universe as once an infinite expansion of formless and diffused matter. At one point of this he supposes a single centre of attraction set up, and by strict deductions from admitted dynamical principles shows how this must result in the development of a prodigious central body surrounded by systems of solar and planetary worlds in all stages of development. In vivid language he depicts the great world-maelstrom widening the margins of its prodigious eddy in the slow progress of millions of ages, gradually reclaiming more and more of the molecular waste, and converting chaos into cosmos. But what is gained at the margin is lost in the centre ; the attractions of the central systems bring their constituents together, which then by the heat evolved are converted once more into molecular chaos. Thus the worlds that are, lie between the ruins of the worlds that have been and the chaotic materials of the worlds that shall be ; and in spite of all waste and destruction Cosmos is extending his borders at the expense of Chaos.

Kant's further application of his views to the earth itself is to be found in his 'Treatise on Physical Geography'[1] (a term under which the then unknown science of geology was included), a subject which he had studied with very great care and on which he lectured for many years. The fourth section of the first part of this Treatise is called " History of the great changes which the earth has formerly undergone and is still undergoing," and is in fact a brief and pregnant essay upon the principles of geology. Kant gives an account first " of the gradual changes which are now taking place " under the heads of such as are caused by earthquakes, such as are brought about by rain and rivers, such as are effected by the sea, such as are produced by winds and frost, and, finally, such as result from the operations of man.

The second part is devoted to the " Memorials of the changes which the earth has undergone in remote antiquity." These are enumerated as :—A. Proofs that the sea formerly covered the whole earth. B. Proofs that the sea has often been changed into dry land and

[1] Kant's 'Sämmtliche Werke, Bd. VIII. p. 145.

working of a clock is a model of uniform action ; good time-keeping means uniformity of action. But the striking of the clock is essentially a catastrophe ; the hammer might be made to blow up a barrel of gunpowder, or turn on a deluge of water ; and, by proper arrangement, the clock, instead of marking the hours, might strike at all sorts of irregular intervals, never twice alike in the intervals, force, or number of its blows. Nevertheless all these irregular and apparently lawless catastrophes would be the result of an absolutely uniformitarian action ; and we might have two schools of clock-theorists, one studying the hammer and the other the pendulum.

Still less is there any necessary antagonism between either of these doctrines and that of Evolution, which embraces all that is sound in both Catastrophism and Uniformitarianism, while it rejects the arbitrary assumptions of the one and the, as arbitrary, limitations of the other. Nor is the value of the doctrine of Evolution to the philosophic thinker diminished by the fact that it applies the same method to the living and the not-living world, and embraces in one stupendous analogy the growth of a solar system from molecular chaos, the shaping of the earth from the nebulous cubhood of its youth, through innumerable changes and immeasurable ages, to its present form, and the development of a living being from the shapeless mass of protoplasm we term a germ.

I do not know whether Evolutionism can claim that amount of currency which would entitle it to be called British popular geology ; but, more or less vaguely, it is assuredly present in the minds of most geologists.

Such being the three phases of geological speculation, we are now in a position to inquire which of these it is that Sir William Thomson calls upon us to reform in the passages which I have cited.

It is obviously Uniformitarianism which the distinguished physicist takes to be the representative of geological speculation in general. And thus a first issue is raised, inasmuch as many persons (and those not the least thoughtful among the younger geologists) do not accept strict Uniformitarianism as the final form of geological speculation. We should say, if Hutton and Playfair declare the course of the world to have been always the same, point out the fallacy by all means, but in so doing do not imagine that you are proving modern geology to be in opposition to natural philosophy. I do not suppose that, at the present day, any geologist would be found to maintain absolute Uniformitarianism, to deny that the rapidity of the rotation of the earth *may* be diminishing, that the sun *may* be waxing dim,

after all, the qualifying phrase "some such period" may not necessitate the assumption of more than $\frac{1}{150}$, or $\frac{1}{240}$, or $\frac{1}{382}$ of an inch of deposit, per year, which, of course, would give us still more ease and comfort.

But it may be said that it is biology, and not geology, which asks for so much time—that the succession of life demands vast intervals; but this appears to me to be reasoning in a circle. Biology takes her time from geology. The only reason we have for believing in the slow rate of the change in living forms is the fact that they persist through a series of deposits which geology informs us have taken a long while to make. If the geological clock is wrong, all the naturalist will have to do is to modify his notions of the rapidity of change accordingly. And I venture to point out that, when we are told that the limitation of the period during which living beings have inhabited this planet to one, two, or three hundred million years requires a complete revolution in geological speculation, the *onus probandi* rests on the maker of the assertion, who brings forward not a shadow of evidence in its support.

Thus, if we accept the limitation of time placed before us by Sir W. Thomson, it is not obvious, on the face of the matter, that we shall have to alter, or reform, our ways in any appreciable degree; and we may therefore proceed with much calmness, and indeed, much indifference to the result, to inquire whether that limitation is justified by the arguments employed in its support.

These arguments are three in number:—

I. The first is based upon the undoubted fact that the tides tend to retard the rate of the earth's rotation upon its axis. That this must be so is obvious, if one considers roughly that the tides result from the pull which the sun and the moon exert upon the sea, causing it to act as a sort of break upon the rotating solid earth.

Kant, who was by no means a mere "abstract philosopher," but a good mathematician and well versed in the physical science of his time, not only proved this in an essay of exquisite clearness and intelligibility, now more than a century old,[1] but deduced from it some of its more important consequences, such as the constant turning of one face of the moon towards the earth.

But there is a long step from the demonstration of a tendency to the estimation of the practical value of that tendency, which is all

[1] "Untersuchung der Frage ob die Erde in ihrer Umdrehung um die Achse, wodurch sie die Abwechselung des Tages und der Nacht hervorbringt, einige Veränderung seit den ersten Zeiten ihres Ursprunges erlitten habe, &c."—Kant's 'Sämmtliche Werke,' Bd. I. p. 178.

thick, enough to give 1·1 foot of water over those areas, or 0·006 of a foot of water if spread over the whole globe, which would in reality raise the sea-level by only some such undiscoverable difference as $\frac{3}{4}$ of an inch or an inch. This or the reverse, which we believe might happen any year, and could certainly not be detected without far more accurate observations and calculations for the mean sea-level than any hitherto made, would slacken or quicken the earth's rate as a time-keeper by one-tenth of a second per year." (*L. c.*, p. 27.)

I do not presume to throw the slightest doubt upon the accuracy of any of the calculations made by such distinguished mathematicians as those who have made the suggestions I have cited. On the contrary, it is necessary to my argument to assume that they are all correct. But I desire to point out that this seems to be one of the many cases in which the admitted accuracy of mathematical processes is allowed to throw a wholly inadmissible appearance of authority over the results obtained by them. Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data.

In the present instance it appears to be admitted:—

1. That it is not absolutely certain, after all, whether the moon's mean motion is undergoing acceleration, or the earth's rotation retardation.[1] And yet this is the key of the whole position.

2. If the rapidity of the earth's rotation is diminishing, it is not certain how much of that retardation is due to tidal friction,—how much to meteors,—how much to possible excess of melting over accumulation of polar ice during the period covered by observation, which amounts, at the outside, to not more than 2600 years.

3. The effect of a different distribution of land and water in modifying the retardation caused by tidal friction, and of reducing it, under some circumstances, to a minimum, does not appear to be taken into account.

4. During the Miocene epoch the polar ice was certainly many feet thinner than it has been during or since the Glacial epoch. Sir W. Thomson tells us that the accumulation of something more than a foot of ice around the poles (which implies the withdrawal of, say, an inch of water from the general surface of the sea) will cause the earth to rotate quicker by one-tenth of a second per annum. It would

[1] It will be understood that I do not wish to deny that the earth's rotation *may be* undergoing retardation.

appear, therefore, that the earth may have been r
the whole period which has elapsed from the co
Glacial epoch down to the present time, one, or m
num quicker than it rotated during the Miocene e

But, according to Sir W. Thomson's calculatic
will only account for a retardation of 22" in a cent
of a second per annum.

Thus, assuming that the accumulation of pola
cene epoch has only been sufficient to produce ten
a coat of ice one foot thick, we shall have an accel
covers all the loss from tidal action, and leaves a
second per annum in the way of acceleration.

If tidal retardation can be thus checked and o
temporary conditions, what becomes of the confide
upon the assumed uniformity of tidal retardation,
million years ago the earth must have been rotatin
as fast as at present, and, therefore, that we ge
rect opposition to the principles of Natural Philos
geological history over that time?

II. The second argument is thus stated by Sir W
article, by myself, published in 'Macmillan's Ma
1862, on the age of the sun's heat, explains resul
into various questions as to possibilities regarding t
that the sun could have, dealing with it as you w
or a piece of matter, only taking into account the
which showed it to be possible that the sun may
minated the earth for as many as one hundred m
the same time rendered it almost certain that he h
the earth for five hundred millions of years. The
necessarily very vague; but yet, vague as they ar
that it is possible, upon any reasonable estimate f
properties of matter, to say that we can believe t
illuminated the earth for five hundred million years.

I do not wish to "Hansardize" Sir William T
much stress on the fact that, only fifteen years ago
totally different view of the origin of the sun's heat,
the energy radiated from year to year was supplied
—a doctrine which would have suited Hutton perfe
that so eminent a physical philosopher has thus r
opposite to those which he now entertains, and tha
own estimates to be "very vague," justly entitle
those estimates if any distinct facts on our side

However, I am not aware that such facts exist. As I have already said, for anything that I know, one, two, or three hundred millions of years may serve the needs of geologists perfectly well.

III. The third line of argument is based upon the temperature of the interior of the earth. Sir W. Thomson refers to certain investigations which prove that the present thermal condition of the interior of the earth implies either a heating of the earth within the last 20,000 years of as much as 100° F., or a greater heating all over the surface at some time further back than 20,000 years, and then proceeds thus :—

" Now, are geologists prepared to admit that, at some time within the last 20,000 years, there has been all over the earth so high a temperature as that? I presume not; no geologist—no *modern* geologist—would for a moment admit the hypothesis that the present state of underground heat is due to a heating of the surface at so late a period as 20,000 years ago. If that is not admitted, we are driven to a greater heat at some time more than 20,000 years ago. A greater heating all over the surface than 100° Fahrenheit would kill nearly all existing plants and animals, I may safely say. Are modern geologists prepared to say that all life was killed off the earth 50,000, 100,000, or 200,000 years ago? For the uniformity theory, the further back the time of high surface-temperature is put the better; but the further back the time of heating, the hotter it must have been. The best for those who draw most largely on time is that which puts it furthest back; and that is the theory that the heating was enough to melt the whole. But even if it was enough to melt the whole, we must still admit some limit, such as fifty million years, one hundred million years, or two or three hundred million years ago. Beyond that we cannot go." (*L. c.*, p. 24.)

It will be observed that the " limit " is once again of the vaguest, ranging from 50,000,000 years to 300,000,000. And the reply is, once more, that, for anything that can be proved to the contrary, one or two hundred million years might serve the purpose, even of a thorough-going Huttonian uniformitarian, very well.

But if, on the other hand, the 100,000,000 or 200,000,000 years appear to be insufficient for geological purposes, we must closely criticise the method by which the limit is reached. The argument is simple enough. *Assuming* the earth to be nothing but a cooling mass, the quantity of heat lost per year, *supposing* the rate of cooling to have been uniform, multiplied by any given number of years, will give the minimum temperature that number of years ago.

But is the earth nothing but a cooling mass, "like a hot-water jar

XXIV

ON THE ETHNOLOGY AND ARCHÆOLOGY OF INDIA

(OPENING ADDRESS OF THE PRESIDENT)

The Journal of the Ethnological Society of London, new series, vol. i., 1869, *pp.* 89–93. (*Delivered March 9th*, 1869.)

THE Council of the Society over which I have the honour to preside, proposes to direct public attention to the desirableness of subjecting the physical characters, the languages, the civilisation, the religions, in short, the ethnology, of the various peoples over whom the rule of Britain extends, to systematic investigation.

To this end, we propose to hold a series of meetings in this and succeeding sessions, each of which shall be devoted to the ethnology of one or other of the British possessions. On these occasions we earnestly invite the co-operation of persons who have been, or are likely to be, resident in the countries under consideration. We hope that the co-operation we seek will take two forms. On the one hand, we trust that those who, as old residents, possess information, will give it to us for the benefit of the public. And, on the other hand, that those who are going to be residents abroad will attend for the purpose of learning how easy for them it is to serve science and forward the solution of great and interesting problems by the expenditure of a small amount of thoughtful and intelligent attention.

The first of these meetings is that which, by the permission of the Director-General, is held in the Theatre of the Museum of Practical Geology, to-night. It seemed fitting that the greatest of the possessions of the Empire should be the first to claim our attention ; and, on seeking for that co-operation which was so essential to the success of our plans among persons familiar with India, we found a store of valuable materials most liberally and kindly thrown open to us

the most massive and the highest mountains in the world, forming a great wall of snow-peaks a thousand miles long. On the north-west lie the steep and barren cliffs of Beloochistan and Affghanistan, pierced by only two considerable passes, that of Bholan and that of Caubool.

Altogether, it would be difficult to find, in the whole world, another area so vast and so hedged in and cut off from the rest of the world on all sides by natural barriers.

Within its fence of mountain and sea, India itself is subdivided by Nature into two great regions which differ in almost every respect. The first is the "river plain," which extends from the Arabian Gulf to the Bay of Bengal, and bears the waters of the Indus to the west, those of the Ganges to the east. It is a mass of alluvial soil, composed of mud or sand and vegetable *débris*, which has been brought down from all the adjacent highlands by the affluents of the two great rivers. The water-shed between the two river basins does not rise to a thousand feet above the level of either sea, and lies to the north and west of Delhi. From this region most of the waters flow east to the Jumna and west to the Sutlej; but a few streams swell neither of these great torrents, but meet to form a river famous in Hindoo history—the Saraswati, which takes a north-west course, and finally becomes lost in the sands of that great desert which lies west of the Indus.

The India of most people's imaginations—the India of Clive and of Hastings—is that part of the great plain which lies east of the Saraswati, and forms the river basin of the Jumna and of the Ganges. It is one of the most fertile and richly endowed countries in the world, "the land of black antelope," the holy land of Brahminism. There lie Delhi, Lucknow, and Agra; there once flourished the great Hindoo and Mahomedan emperor.

The Western river basin on the other hand, though rich and fertile enough, in its upper region, the Punjab, after the five rivers have joined into the Indus, becomes a long stretch of frightful deserts which bound the river on either hand and bar the passage from west to east.

From the Gulf of Cutch, on the eastern side of the great desert of Sind, a range of moderate elevation—the Arravalli hills—runs north-east to near Delhi. A divergent line drawn east by north from Gujerat to near the Ganges, marks the direction of a more lofty range, the Vindhya mountains. Enclosed between them lies a great extent of hilly country, all of whose rivers flow into the Jumna, constituting the provinces of Malwa, Gwalior, and Bundelcund. The Vindhya mountains form the north wall of a great valley, which takes a nearly easterly and westerly direction, and along which, from east to west,

In Europe, two distinct types of these pale-faced people are to be observed: the one having black eyes and hair, and sallow skins; the other, with yellow hair, blue eyes, and white ruddy skins. Both these types are traceable to the frontiers of Hindostan, the dark among the Afghans, the fair among the Siahposh, who live in the inaccessible valleys of the Hindoo Koosh. But I do not know that there is any evidence to show that the early Aryan settlers in Hindostan possessed one complexion rather than the other; certainly the dark pale type is that which predominates almost exclusively among the high caste Hindoos of the present day.

All the testimony of history, and all the internal evidence afforded by Sanscrit literature, go to prove that the Aryans were originally the kith and kin of the Persians, and that they invaded Hindostan from the north-west, becoming first possessed of Sind, and then, through long ages of battle with the pre-existing population, making their way across the Saraswati, and ultimately to the lower course of the Ganges.

There can be no reasonable doubt that this pre-existing population was in great measure Dravidian, though whether it was already mixed with a Mongoloid element from the north-east or not, does not appear. In part, mixing with the conquerors and modifying their physical characters, their language, and their religion into endless shades of diversity; while, in part, extirpated, and, in part, driven to the shelter of their savage fastnesses among the hills of the Dekhan, the Dravidians remain, like the Celts of Brittany and of Wales, a fragmentary and dispossessed primitive population—the hill tribes of whom we shall hear so much to-night.

XXV

ON THE ETHNOLOGY AND ARCHÆOLOGY OF NORTH AMERICA

(ADDRESS OF THE PRESIDENT)

The Journal of the Ethnological Society of London, new series, vol. i., 1869. *pp.* 218–221. (*Delivered April 13th*, 1869.)

THE broad physical features of the American continent may be described in a few words. Near its eastern coast a range of mountains runs nearly north and south from the Arctic Ocean to Cape Horn, interrupted only by the low ground of the Isthmus of Panama; while, in the Andes, its peaks reach heights surpassed only by the greatest elevations of the Himalayan range. Westward of this range, the general slope of the continent is steep and rapid to the Pacific; eastward, it is slow and gradual, giving rise to vast and, usually, fertile plains, bounded by the North and South Atlantic Oceans. But, in both North and South America, each plain is interrupted towards the east by mountain-ranges of a secondary importance, the Apalachians in the north, and the Brazilian mountains in the south.

Vast rivers, separated only by very low watersheds, drain the plains of the two divisions of the American continent—some running to the north, as the Mackenzie and the Orinoko; some to the east, as the St. Lawrence and the Amazons; and others trending more southwardly, as the Mississippi and the Rio de la Plata. By these rivers almost all parts of the American plains are rendered easily accessible from the east and north coasts; while, on the other hand, there are, in most regions, considerable obstacles to migration from the west coast eastwards into those plains.

On the eastern coast, the greater part of America is separated from the nearest land by a wide ocean, containing but very few islands, and

these altogether in the Old-World side of the middle of the Atlantic. Only in the extreme north do the Shetlands, the Faroe islands, and Iceland present a widely interrupted chain of stations between Western Europe and Greenland. On the western side, not only is the greater part of the coast of America separated by many hundred miles of sea from the nearest Polynesian islands, but the ordinary course of the trade winds is against navigation from the west. Still more than on the eastern side, however, are the obstacles to immigration removed on the north-west coast; not only is the Strait of Behring very narrow, but far to the south of it, in a much milder climate, the chain of the Aleutian islands offers an almost continuous bridge between Asia and America, over which immigrants could readily pass to a region which is separated from the eastern plain only by the low and easily traversed northern extremity of the great backbone of the continent.

Thus, supposing the American continent to have been peopled at a period subsequent to that at which it had attained its present form and relations to the Old World, it is vastly more probable that it was stocked with men from Northern Asia than from any other region.

But it is quite as reasonable to adopt a different supposition. From the Mexican frontier to the Arctic Ocean the fauna of North America abounds in species representing, if not identical with, those of Europe and Asia; while, at the same time, it presents an admixture of forms of a totally different and especially American character. South of the Mexican frontier the purely American groups increase in number and variety as the Old-World forms disappear; and the fauna of the vast region which stretches from Mexico to Cape Horn is as peculiar as that of Australia.

During the glacial epoch the greater part of North America shared the fate of Northern Asia and Europe, having been covered with ice, and partly submerged; and its present animal population is, without doubt, the result of migration subsequent to that period, in large part from the Old World, and in less degree from the region south of Mexico, or "Austro-Columbia." The Austro-Columbian fauna, as a whole, therefore existed antecedently to the glacial epoch. Did man form part of that fauna? To this profoundly interesting question no positive answer can be given; but the discovery of human remains associated with extinct animals in the caves of Brazil, by Lund, lends some colour to the supposition that he may have done so. Assuming the supposition to be correct, we should have to look in the human population of America, as in the fauna generally, for an indigenous or Austro-Columbian element and an immigrant, or "Arctogeal," element.

America, the conditions which gave rise to the development of a high state of civilization seem to have been the same in the New World as in the Old. The fertile valley of the Nile and the shores of the Mediterranean determined the locality of the earliest great civilized communities of the Old World. In the Mexican Gulf, sheltered by the great breakwater of the West-India Islands, and artificially warmed by the equatorial current, America has her Mediterranean, and, in the Mississippi, her Nile. And here, unknown ages before Columbus, native agriculture converted the maize and the potato into the staple food of a numerous population, invented cocoa, chocolate, and pulque in place of tea, coffee, and wine, applied cotton to the uses of flax and silk, reared massive works in hewn and sculptured stone (the equals of which, like the hieroglyphic symbols with which they are covered, must be sought in ancient Egypt), and organized a complex and peculiar system of social organization.

and the Meckelian Cartilage in Crocodiles," which was followed on the 7th January, 1869, by a fourth, "Upon the Auditory Ossicles of Chelonia, Lizards, and Ophidia, as well as upon the cavities of the Lower Jaw of the Crocodile," which seemed to me to demand immediate attention; for the quadrate bone of the Crocodile cannot possibly represent either the incus, or the malleus, if the statement of anatomical facts made by Prof. Peters is correct.

I therefore proceeded to the verification of his descriptions with much interest and a little anxiety; but after dissecting the skulls of several young Crocodiles with great care, I must declare my conviction that Prof. Peters is in error as to the facts, and, therefore, that the argument he bases upon them falls to the ground.

The able anatomist Stannius first drew attention to the pneumaticity of the lower jaw in the Crocodile, in the following terms:—

"The *os articulare* of the lower jaw is distinguished by its pneumaticity; its great hollow cells communicate, by a canal which lies at the back of the *os tympanicum* [quadratum], with the air-chambers of the cranial bones. The lowest part of the canal in question forms a groove in the dry skull. This, in the fresh skull, is converted into a soft tube; and a free membranous tube leads into a hole placed on the inner side of the surface of the *os articulare*." (Stannius, 'Handbuch d. Zootomie,' Zweiter Theil. Amphibien, p. 58, 1856.)

Prof. Peters adds to this account of the matter the following statements ('Monatsberichte,' 1869, pp. 593, 594):—

"That Meckel's cartilage, which persists throughout life in the Crocodile, becomes very slender posteriorly, and passes through the hole in the *os articulare*; that this slender cartilage then ascends upon the posterior and upper face of the quadrate bone enclosed in a membranous sheath; that, having reached the posterior edge of the membrana tympani, "it becomes connected witha cartilaginous plate, the narrow middle part of which is bent inwards towards the *columella auris*, with the external end of which it is connected by a joint. The broadest part of this cartilaginous plate is shaped like an axe-head, is directed perpendicularly against the *membrana tympani*, and forms, at the anterior end of its convex outer edge, a little plate which lies in the middle of the *membrana tympani*. It causes this region of the membrane to project slightly outwards, in the adult as well as in the young, and gives attachment to a filiform tendon which proceeds from the posterior boundary of the tympanic cavity. The other part of the cartilaginous plate bends away at an obtuse angle from the former, and has also the form of an axe-head, the convex edge of which, however, is narrower, and is applied below

fere quatuor lineas longum, operculo triangulari instructum. In altera extremitate in cartilaginem tripartitam desinit, cujus una pars, ut dixi, in membrana media tympani adhæret, aliæ duæ in falce membranam hancce excipiunt." (Windischmann, De penitiori auris in Amphibiis structura. 1831.)

The "triangular ligament" of Cuvier is clearly the "*malleus*" of Prof. Peters; and the same part seems to be meant by the "aliæ duæ" of Windischmann.

What Cuvier terms the "stem" of the stapes of the Crocodile is more or less completely ossified; but I find, in all cases, that it passes directly into the cartilaginous axehead-like plate, the convex edge of which is connected with the *membrana tympani*. There is no trace of the joint described by Prof. Peters in any of the specimens I have examined; neither have I been able to see anything of the "filiform tendon" which is said to "proceed from the posterior boundary of the tympanic cavity."

Where the outer end of the stem of the stapes widens out into this process for the tympanic membrane, which I shall call the "*extrastapedial*" cartilage (fig. 1, *E.St*), it gives off, upwards and backwards, a slender cartilaginous prolongation, which expands and becomes the second "axehead-like" process, called "*malleus*" by Prof. Peters (*S.St*); but I have not been able to detect any trace of what Prof. Peters calls "a little short cylindrical intermediate cartilage" between this and the stem of the stapes. In all the specimens I have examined there is complete cartilaginous continuity between the two.

What Prof. Peters terms the "cartilaginous margin of the tympanum" is a backward prolongation of the cartilage of the periotic region of the skull, which corresponds in part, if not wholly, with the *tegmen tympani* of a mammal. It may be called the "parotic process" (fig. 1, *Pc.c*); and in the adult it is converted, in great measure, into a slender and curiously curved process of the pro-otic, and, in part, into a process of the so-called exoccipital bone. Muscular fibres, which represent the *stapedius* muscle (fig. 2, *Stp*), proceed from this cartilaginous margin, or the corresponding bones, to the margin and outer face of the cartilage called "*malleus*" by Prof. Peters, but which I shall term the "*suprastapedial*" cartilage (*S.St*). The inner surface of the posterior edge of the suprastapedial cartilage is thus closely connected with the posterior part of the parotic process of the skull, while its anterior end comes into contact with the quadrate bone, which is connected with the front part of the same process.

the digastric muscle covers it; above, it abuts against the lower and posterior walls of the tympanic cavity. Can there be any doubt, therefore, that it answers to the styloid cartilage, or proximal end of the hyoidean arch, in a mammal?

A fold of the lining membrane of the tympanum (*a*, fig. 2) somewhat obscures the junction of the extrastapedial and surprastapedial cartilages with the styloid cartilage; but by detaching the parts and saturating them with glycerine and caustic soda, it is plainly demonstrable that the styloid cartilage is only connected by fibrous tissue, and, indirectly, by the *stapedius*, with the *stapes*.

Thus, then, in the Crocodile, the connexion between the *articulare* and the *stapes*, supposed by Prof. Peters, does not exist; but there is a very close connexion between the *stapes* and a cartilage which

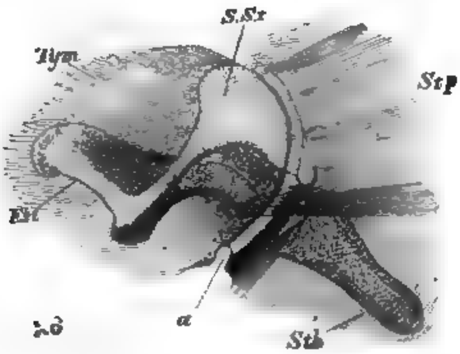


Fig. 2.—Inner view of the tympanic membrane (*Tym*) of a young *Crocodilus biporcatus*, with the attached stapedial cartilages (*S.St*, *E.St*), the fold (*a*), the styloid cartilage (*Sth*), and the stapedius muscle (*Stp*). The stem of the stapes is cut through just where it begins to ossify.

distinctly represents the upper extremity of the hyoidean arch; and, so far from the Crocodile furnishing any ground for the supposition that the *stapes* and its appendages are modifications of the skeleton of the first visceral arch, as is suggested by Prof. Peters, the facts observed strongly suggest that these parts are modifications of the skeleton of the second visceral arch.

This suggestion is converted into a certainty when that remarkable Lizard *Sphenodon punctatum* (=*Hatteria*) is examined. Dr. Günther's statement (Phil. Trans. 1867, p. 620), that, in this Lizard, the stapes is "attached by a fibro-cartilaginous ligament" to the anterior cornu of the hyoid, strongly attracted my attention when I read his valuable memoir on this reptile; and having had an opportunity, thanks to him, of examining into the question for myself, I can fully confirm his assertion.

becomes connected with the skull; the concavity is filled up by aponeurotic fibres.

The aponeurotic expansion which has been mentioned covers the outer end of the tympanic cavity; when it is removed, the proximal end of the cornu of the hyoid is seen to expand, and becomes converted into a broad plate of cartilage, the curved margin of which

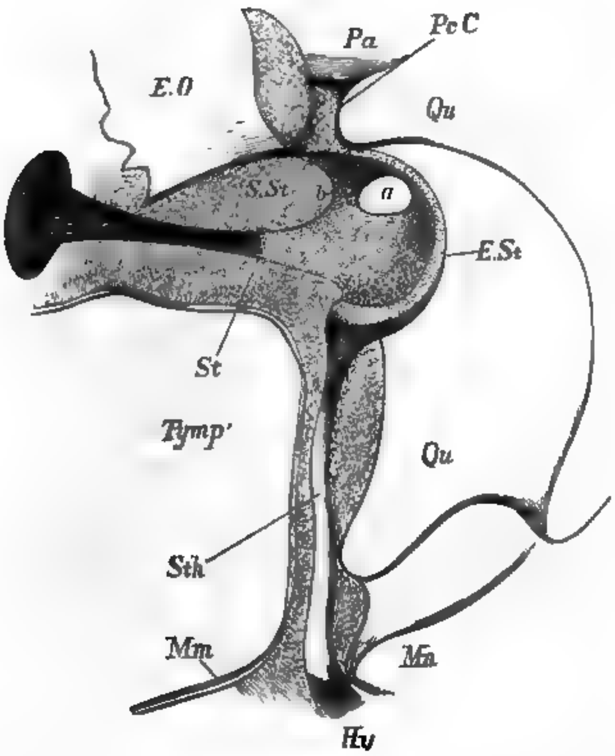


Fig. 4.—The tympanic cavity and the adjacent parts laid open from behind, and the aponeurotic expansion removed, in *Sphenodon punctatum*. Five times the size of nature.

The letters as in fig. 3, except:—*Pa.* Parietal. *Pt.C.* Parotic cartilage. *S.St.* suprastapedial cartilage. *b.* Origin of this cartilage from the stapes. *a.* Foramen included between it and the extrastapedial. *Mm.* The cut edge of the mucous membrane. *Tymp.* The pharyngeal recess which takes the place of the tympanic cavity. The exoccipital is supposed to be broken away to show the fenestral end of the stapes.

gives rise to the "scroll." Internally the plate is continued into the stem of the stapes, and speedily becomes ossified (fig. 4). There can be no doubt, therefore, that it corresponds with the extrastapedial cartilage of the Crocodile.

What answers to the axehead-shaped suprastapedial cartilage of the Crocodile is the upper process of the cartilaginous part of the stapes (*S. St*), which, however, passes into the extrastapedial car-

I see no room for any doubt that this ascending process and the elastic ligament represent the suprastapedial cartilage of the Crocodile.

As in the Crocodile, the posterior end of the extrastapedial cartilage is closely connected by fibrous tissue with the posterior boundary of the tympanum and the tympanic membrane; but I have been unable to discover even a rudiment of a styloid cartilage. The inferior, free, curved process of the stem of the stapes, which may be termed *infrastapedial* (*I.St*) seems at first to answer to that cartilage; but its relations are quite different.

Thus the Lizard, the Crocodile, and the Bird present a complete series of modifications of the parts described. In *Sphenodon* the

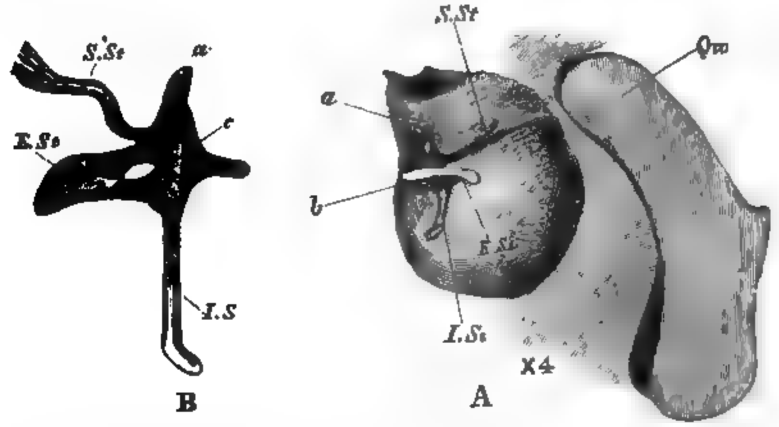


Fig. 5.—A. The auditory region, the tympanic membrane being taken away, in a Fowl. *Qu.* Quadratum. *S.St.* Platner's ligament. *E.St.* The extrastapedial cartilage, the edge of which is fixed to the tympanic membrane. *b.* The end of the extrastapedial which is fixed to the posterior boundary of the tympanum. *c.* The ascending process. *I. St.* The infrastapedial process.

B. The outer end of the stapes separated from the stem where the latter begins to be ossified. Turned round and magnified.

hyoidean arch is histologically continuous throughout its entire length; and in its upper part is a rod of cartilage which, at one point, passes into the *stapes*.

In the Crocodile, the upper part of the hyoidean cornu has no direct connexion with the lower, and the rudimentary styloid part is not histologically continuous with the stapedial part.

In the Bird the styloid part has vanished, and the suprastapedial is represented only by fibrous tissue.

Such developmental evidence as exists is entirely in accordance with the view of which these anatomical facts appear to me to afford a sufficient demonstration.

(the suprastapedial cartilage) is really the quadratum, the articulation of which with Meckel's cartilage takes place in the ordinary way, and that *i*, called the *columella* (or *stapes*), is neither more nor less than the pterygo-palatine cartilage. The most cursory glance is sufficient to prove that the inner extremity of *i* must needs lie beneath and internal to the eye, and cannot by any possibility come near the *fenestra ovalis*. It therefore seems to be impossible that *i* can be the *stapes*.

Bearing clearly in mind the demonstration now given that the *stapedial apparatus* (if I may so term the *stapes* with its appendages) of the *Sauropsida* is connected entirely with the hyoidean arch, and that it consists of a stem terminating, at one end, in the plate which covers the *fenestra ovalis*, and, at the other, in sundry processes of cartilaginous or fibrous texture, one of which is connected with the tympanic membrane (when that structure exists), while another passes up to be united with the otic region of the skull, close to the articulation of the quadrate bone, we may pass to the consideration of the homologies of these parts in the ordinary *Mammalia*, of which Man may be taken as an example.

The Okenian view, adopted by Prof. Peters, assumes that the *ramus* of the mandible of the mammal answers to the whole *ramus* of the mandible of a Sauropsidan, that the tympanic bone of the mammal answers to the quadrate bone of the Sauropsidan, and that the *ossicula auditûs* of the mammal, or the *malleus*, *incus*, and *stapes*, collectively, correspond with the stapedial apparatus of the Sauropsidan.

The Reichertian view, which I have hitherto supported, assumes that the *ramus* of the mandible of the mammal answers only to part of the *ramus* of the Sauropsidan, inasmuch as the articular piece of the Sauropsidan mandible answers to the *malleus* of the mammal—that the quadrate bone of the Sauropsidan is the homologue of the *incus* of the mammal—and, consequently, that the stapedial apparatus of the Sauropsidan is entirely represented by the *stapes* of the mammal. In the place of the tympanic bone of the mammal there are only the ossifications which are found in the membranous frame of the tympanic membrane in some *Sauropsida* (*e.g.* many birds) and *Amphibia*.

The arguments by which this view has been supported are briefly these:—

In the Sauropsidan embryo a rod of cartilage occupies the first visceral arch on each side, and meets its fellow in the middle line. The rod becomes jointed, and the part on the distal side of the joint is converted into Meckel's cartilage, while that on the proximal

needs answer to that between the *quadratum* and the *articulare* of the Sauropsidan ; and as the *incus* and the *malleus* ossify, nothing can seem closer than the resemblance which they bear to the *quadratum* and the *articulare* respectively. Hence Reichert conceived that the *quadratum* was the homologue of the *incus*, and the *malleus* that of the *articulare*, and I have followed him. But the study of *Sphenodon* and of the Crocodile has led me to believe that we have fallen into an error.

It is admitted, on all hands, and indeed cannot be disputed, that

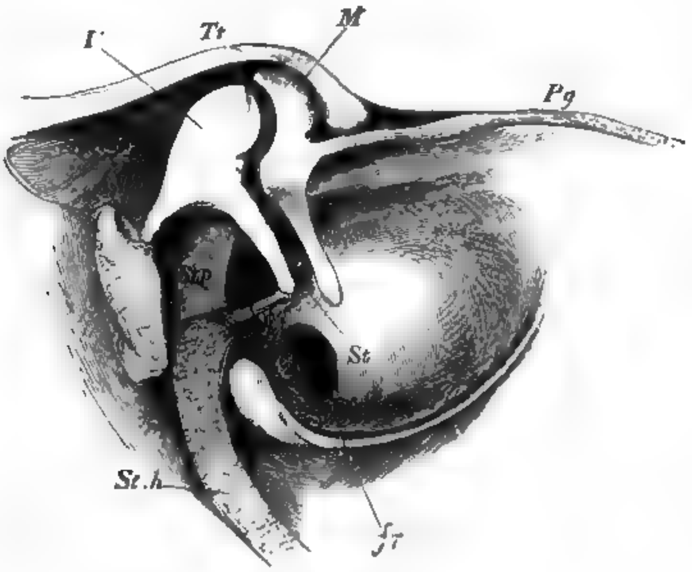


Fig. 6—The ear-bones and the adjacent parts (the tympanic membrane, the tympanic bone or the squamosal, and the ramus of the mandible being removed) of a human fœtus at about the 5th month. Magnified four diameters.

T.t. The *tegmen tympani*, part of the periotic mass. *M.* The malleus, with its Folian process (*Pg*) passing into Meckel's cartilage. *I.* The incus. *St.* The stapes, with the cartilaginous process *a*, which extends from the region of the orbicular bone into the *stapedius* muscle, *Stp.* *St.h.* The stylo-hyal or styloid process, still quite cartilaginous. *fr.* The foramen rotundum.

the stem and fenestral plate of the stapedial apparatus of the Sauropsidan answer to the crura and fenestral plate of the *stapes* of an ordinary mammal. But the *incus* of a mammal is related to the *stapes* on the one hand, and to the walls of the tympanic cavity on the other, nearly as the suprastapedial of a Crocodile is to the same parts ; if the *incus* remained cartilaginous the resemblance would be complete. On the other hand, in the human fœtus, the *stapes* has a cartilaginous prolongation which is embraced by the *stapedius* muscle, and contributes to reduce the interval between the *stapes* and the upper

The modification of Reichert's view which I now propose completely removes a difficulty which has often presented itself to my own mind, and which is urged with much force by Prof. Peters, in his first two papers. If the *incus* be the homologue of the *quadratum*, why does it become so small and insignificant in the Marsupials and Monotremes, which, in so many respects, approach the *Sauropsida*? This question I have always felt could only be met by another. Why, if the *ossicula auditûs* of the mammal do not represent bones of much more importance in the *Sauropsida*, does the *malleus* attain such a vast size in the *Monotremata*?

If the *malleus* is, as I have endeavoured to prove it to be, the homologue of the quadratum, the last question receives an obvious answer; and no less readily is it intelligible why the *incus* should be reduced, seeing that the suprastapedial is always insignificant in size, and may even become a mere fibrous band, in the *Sauropsida*.

I may mention, incidentally, that *Echidna* presents other anomalies than those which have been described by Prof. Peters and others. The muscle which plays the part of the *tensor tympani* is very large and arises from the base of the skull, where it forms the roof of that posterior and inner region of the tympanic cavity which is bounded below by the pterygoid. The strong tendon of this muscle passes outwards, and is inserted into the upper aspect of that knee-like process of the *malleus* which is fixed to the tympanic membrane.

The cartilaginous "styloid" end of the hyoidean arch is fixed into the wall of the outer and posterior end of the tympanic cavity, very near the *incus* and *stapes*; but I can find neither a *stapedius* muscle, nor any ligament representing it.

It will be observed that the proximal end of the skeleton of the first visceral arch (whether it be osseous, cartilaginous, or fibrous), like that of the second, remains attached to one and the same part of the skull, viz. the outer and upper wall of the periotic mass, external to the vestibular sac, throughout the *Mammalia* and the *Sauropsida*. In mammals the proximal skeletal elements of the arches (*malleus* and *incus*) are very generally equal, or the *incus* may be the smaller.

In the *Sauropsida*, the suprastapedial (= *incus*) is always smaller than the *quadratum* (= *malleus*).

In Teleostean and Ganoid fishes, and in the Sharks, the general relations of the two arches remain unchanged, but their proportions are reversed.

The only vertebrated animals in which a portion of the first visceral cleft remains open throughout life are some *Ganoidei* and most

or wholly, answer to the *incus.* Where, then, is the homologue of the proximal end of the skeleton of the first visceral arch of the fish, if the hyomandibular belongs altogether to the second? I find it in that prolongation of the quadrate cartilage of the Teleostean which ascends in front of the hyomandibular, and is at first quite free from it, but afterwards becomes surrounded and replaced by the metapterygoid which eventually helps to bind it to the hyomandibular.

Thus the puzzling division between the mandibular and the hyoidean parts of the suspensorial apparatus in a fish becomes intelligible as the result of their primarily separate development.

In the osseous fishes the proximal end of the mandibular arch is arrested in its development and loses its direct connexion with the skull; but in the Sharks the ascending portion of the quadrate atrophies altogether, or is represented merely by pre-spiracular cartilages; and the quadrate itself forms only the posterior termination of the palato-quadrate arch, or so-called upper jaw.

In the *Chimæræ, Dipnoi,* and all *Amphibia,* the proximal ends of the cartilaginous first and second visceral arches become united together, at an early period, into a common plate, in which the malleal and incudal elements are not separately distinguishable. In the *Chimæræ, Dipnoi,* and the lower *Amphibia* they remain in this condition throughout life; but in the higher *Amphibia* changes of a most remarkable kind take place, of which I do not now propose to speak, as my friend Mr. Parker is engaged in working out that part of the subject.

I subjoin a tabular view of the homologies of the parts under discussion in the *Mammalia, Sauropsida,* and Teleostean Fishes.

Mandibular arch :—

I. MAMMAL	*Malleus*		*Meckel's cartilage.*
II. SAUROPSIDAN	*Quadratum*	*Articulare*	*Meckel's cartilage.*
III. TELEOSTEAN	*Metapterygoid* and *Quadratum*	*Articulare*	*Meckel's cartilage.*

Hyoidean arch :—

I. MAMMAL	*Incus*	*Stapes*	*Stapedius, Styloid, Hyoid cornu.*
II. SAUROPSIDAN	*Suprastapedial*	*Columella auris*	*Hyoid cornu* (Sphenodon).
III. TELEOSTEAN'	*Hyomandibular*		*Stylo-hyal, Hyoid.*

affinity of the reptile with *Iguanodon* was clear, the extent of that affinity could only be determined by further critical comparisons.

I lost sight of the specimen for a long time; but, some months ago, hearing that it was in Mr. Fellows's keeping in London, I requested Mr. Fox's permission to subject it to more careful study, That permission was very readily and liberally accorded by Mr. Fox, and I now offer the results of this further work to the Society.

The skull (Pl. I. fig. 1, [Plate 28]) when entire and undistorted must have had a length of rather less than four inches (probably about 3·8 or 3·9). The greater portion of the roof and of the right upper maxillary apparatus, with a part of the occipital surface, are displayed. The whole left nasal bone is exposed, together with part of the left præmaxilla and a portion of the left ramus of the mandible.

Two relatively large supratemporal fossæ, each about three-quarters of an inch long and four-tenths of an inch wide, lie at the sides of the parietal region, which is somewhat narrow in the middle, but expands at each end. The parietal bones (*Pa*) are a good deal injured, but they appear to have inclosed an oval median parietal foramen. In front, they unite by a transverse suture with the large frontal bones (*Fr*). Each of these is 1·4 inch long, 0·5 inch broad behind, and rather narrow in front, flattened though slightly concave from side to side, and somewhat convex from before backwards. The inner edges of the two frontal bones are a little raised where they unite in the frontal suture. The nasal bones (*Na*) are very large, being as long as the frontals, and very nearly as broad behind, where they are flattened and continue the direction of the roof of the skull Anteriorly they narrow; and their outer surfaces, becoming convex, look somewhat outwards. Each nasal bone ends by a deeply concave rounded free margin, which bounds the nostril (*N*) above, and sends down a slender process on each side. The inner of these bounds the greater part of the inner side of the nostril, and lies upon, and internal to, the anterior ascending process of the præmaxillary bone (*Pmx*). The outer, in like manner, applies itself to the anterior edge of the ascending process of the maxillary, and forms a part of the outer boundary of the nostril.

The præmaxilla is a very large and remarkable bone. The body, or dentigerous portion, is 0·8 inch long and 0·3 inch high, from the alveolar edge to that which bounds the nostril below. The greater part of the outer surface of the bone is smooth; but towards its anterior end it becomes rugged and pitted, and seems to have been produced downwards and forwards into a short beak-like process.

than halfway from the free edge towards the fang of the tooth. The sixth tooth is that the crown of which is most worn down, the other teeth being to all appearance less worn as they are further from it. The planes of the worn surface of the crowns, as in *Iguanodon*, cut the axis of the tooth at an acute angle, looking inwards as well as downwards. The outer contours of the teeth are convex from above downwards, but hardly so much so as in *Iguanodon.*

At first sight these teeth look very similar to those of *Iguanodon* ; and I was almost disposed to admit their identity with those of the latter genus, after the rapid examination which was alone possible at the meeting of the British Association at Norwich. A more critical comparison, however, has convinced me that the teeth of this reptile are perfectly distinct from those of the great Wealden Dinosaurian.

A large postfrontal separates the orbit from the temporal fossa, and appears to have united with the jugal, of which only an impression remains. A præfrontal is distinguishable at the upper and anterior part of the orbit. Beneath and behind it, lies a broken but very large and curiously curved lacrymal (*La*) which is deeply grooved upon its outer surface, the outer and posterior lip of the groove being much shorter than the inner and anterior lip. An ascending process of the maxilla seems to have articulated with the posterior and inferior end of the lacrymal. The anterior margin of this lacrymal process of the maxilla, the superior margin of the body of the maxilla in front of it, and the posterior margin of that broad nasal process of the maxilla which ascends behind the præmaxilla are all smooth, and evidently natural free edges. Hence there must have been a considerable prælacrymal vacuity (*a*) in the walls of the face. The postfrontal sends a long process backwards, outside an anterior prolongation of the squamosal, the two combining to form the supratemporal zygoma. An impression on the matrix proves that there was a strong infratemporal zygoma formed by the jugal and quadrato-jugal ; and on the left side the under part of this is visible. Remains of large sclerotic plates lie in the orbit. The hinder face of the distal half of the quadrate bone is displayed upon the left side (fig. 4, *Qu*). It is a very strong bone, the articular surface of the condyle measuring not less than half an inch from side to side.

The occipital face of the skull is much injured, but it was evidently directed almost perpendicularly to the upper face. The left parotic process is well displayed, and is proportionally large, being half an inch long and 0·3 inch wide. The base of the skull exhibits the injured basioccipital region, and the more perfect basisphenoid, which possesses two strong, divergent, basipterygoid processes. Against the

formation, about one hundred yards west of Cowleaze Chine, on the north-west coast of the Isle of Wight, in the year 1849;" and the Rev. Mr. Fox informs me that it was found in the same bed as his specimen of *Hypsilophodon*, a stratum which, up to the present time, has yielded no remains of *Iguanodon*.

Two years ago, namely in December 1867, I became convinced, by the evidence of the British Museum specimen itself, that it could not possibly be *Iguanodon*. The form and proportions of the vertebræ, especially of the caudal vertebræ, were quite different; the femur, with many points of similarity, exhibited sundry remarkable differences; and, most important of all, the metatarsus proved the Cowleaze reptile to have, at fewest, four well-developed toes. Again, if, as the describer of the fossil imagined, the bones numbered 66 and 67 (Palæontographical Society, 'Fossil Reptilia of the Wealden,' tab. i.) are the right tibia and fibula, any identification with *Iguanodon* is out of the question, inasmuch as the leg would be much longer than the femur, while in *Iguanodon*, as the Maidstone specimen proves, it is shorter. Thus I made sure that the Cowleaze fossil represented a new genus; and, under the circumstances, the probability that it once formed part of the body of a *Hypsilophodon* is obviously very great. The fortunate preservation of the centrum of a single dorsal vertebra, along with the skull, greatly strengthens this already strong presumption. On comparison with a vertebra from the anterior dorsal region of the specimen in the British Museum, I can find absolutely no difference, except that the vertebra in Mr. Fox's specimen is a shade smaller. The centra of the anterior dorsals in the former are rather less than 0·7 inch long; in the latter the measurement is 0·63 inch. The difference, therefore, is not more than $\frac{1}{20}$ of an inch. The vertebral column of the specimen in the British Museum has been particularly described by Professor Owen; but the caudal vertebræ have been much more completely cleared of the matrix since his memoir was written. The remains of eighteen vertebræ may be made out, in consecutive series, from the cervical to the posterior dorsal region; and the position of the ilium is such, that there can hardly have been more than two or three vertebræ between the hindermost of those which are visible and the sacrum. In the most anterior of these eighteen vertebræ (which may thus, probably, be the twentieth, or twenty-first, from the sacrum), the anterior, escutcheon-shaped, face of the centrum is distinctly convex from side to side, and slightly concave from above downwards, while the posterior face is markedly concave. The neuro-central suture passes through the capitular process; and the tubercular process

springs much higher up upon the arch, beneath the præzygapophysis. the articular face of which looks as much inwards as upwards.[1] It is only the hindermost, or ninth, cervical vertebra of a crocodile which presents these characters. In all the more anterior cervicals the neuro-central suture passes above the process for the capitulum of the rib; I therefore conclude that, in all probability, the anterior vertebra of the *Hypsilophodon* skeleton belonged to the posterior region of the neck. I should think it very possible that there may have been seven, or eight, cervical vertebræ between the most anterior of those preserved and the head. In this case the light head, borne upon the relatively long neck, will have given the forequarters of *Hypsilophodon* much resemblance to those of a Monitor.

Professor Owen concludes, from certain striæ on the articular surfaces of the vertebral centra, that "the vertebral bodies of the Iguanodon *were coarticulated by means of an intervertebral ligament, as in the class Mammalia*;" and he emphasizes this conclusion by putting it in italics. I have little doubt that the vertebral centra of *Hypsilophodon* were so connected; but so are those of a Crocodile, and the fact does not constitute the slightest evidence in favour of the mammalian affinities of the *Dinosauria*.

In resuming my study of the specimen of *Hypsilophodon* in the British Museum, for the purposes of the present paper, the difficulty which had previously presented itself of reconciling what could be seen of the structure of the bones numbered 66 and 67 (tab. i. 'Fossil Reptilia of the Wealden Formation') with what is known of the tibia and fibula of the *Dinosauria* returned very strongly to my mind. On the other hand, my present knowledge of the strange characters of the pelvis in the Dinosaurian reptiles led me to suspect that those bones might prove to be the pubis and ischium *in situ*, and in their natural connexion with the right ilium, the posterior part of which bone (numbered 62 in the plate cited) was conspicuously visible. Careful search revealed the anterior end of the bone overlying the arch of the posterior vertebræ of the dorsal series.

With the permission of the Keeper of the fossil collection, therefore, the specimen was subjected to a further careful removal of the matrix in the requisite directions. The result has been the complete verification of my conjecture, and the specimen now affords a view of the ventral elements of the pelvis in their natural relations (Pl. II. [Plate 28]).

[1] The two following vertebræ have similar characters; but the articular surface of the sixth appears to be slightly concave in front as well as behind. In this vertebra the transverse process springs from the arch, far above the neuro-central suture.

The middle part of the right ilium is covered, and, seemingly, a little crushed in, by the left foot. But its broad postacetabular portion (*b*), and its relatively narrow and pointed præacetabular part (*a*) are completely exposed. I suspect that the ilium is broken in the middle, and, as a consequence, that the distance from the posterior to the anterior ends of the visible parts of the bone (6·6 inches) is somewhat greater than it should be. Hence the acetabulum probably appears to be longer than it naturally is. The postacetabular process (*c*), which should articulate with the ischium, is swollen and thick, but thins off, above and behind, into a thin vertical plate, the posterior curved margin of which is broad and turned in, like a narrow shelf. The præacetabular prolongation is slender, and its broken narrow end (*a*) rests on the arch of the seventeenth vertebra.

The anterior boundary of the acetabulum is formed by a broad, somewhat flattened, facet of bone (*d*), which looks backwards and a little outwards. The osseous mass, of which this forms the posterior aspect, rapidly narrows forwards, and is prolonged above into a slender ridge, or process, with a free rounded end (*a*). In front, it has sinuated free edge; anteriorly and below, it is continued into a slender rod-like pubis (*Pb*), between six and seven inches long, which passes downwards and backwards parallel with the ischium. On the outer surface, in front of the lower part of the articular surface, lies an oval foramen (*e*). The posterior edge of the bone is concave and free. Posteriorly and below, it ends in a broad thin prolongation, which passes backwards, internal to the ischium. The part of the bone which bears the facet answers very well to the præacetabular process of the ilium of *Megalosaurus* and of *Thecodontosaurus* The perforation is indeed somewhat like that which is so generally found in the pubis of Lizards; but, on a future occasion, I hope to be able to show its analogue in the ilium of an undoubted Dinosaurian. If this part of the acetabular wall answers, as I believe it does, to the descending præacetabular process of the ilium, all trace of the suture between it and the pubis has disappeared.

The right ischium (*Is*) lies in undisturbed relation with the pubis. Its acetabular end has a free superior concave edge which bounds the acetabulum below, a broad thin anterior process which overlaps, and is firmly united with the pubis, and a posterior process which becomes very thick behind and articulated with the postacetabular process of the ilium. The shaft of the bone is flattened laterally, and has a thick and rounded posterior edge. Anteriorly it is thinner, and at 2·75 inches from the acetabulum it is produced into a broad and long decurrent process, the free edge of which overlaps the

The length of the left femur is 5·7 inches, or rather less than the length of the hinder eight of the series of dorsal vertebræ. The extreme breadth of the distal end is 1·45 inch, the extreme breadth of the proximal end, from the inner surface of the articular head to the outer surface of the shaft, 1·73 inch. The femur is therefore slightly shorter in proportion to the length of the dorsal vertebræ than in *Iguanodon*. The faces of the inner trochanter look much more directly inwards and outwards, and the whole process has a different shape from that of *Iguanodon*. There is no pit above the inner trochanter, such as exists in *Iguanodon*; and the deep intercondyloid groove, on the anterior face of the distal end, which is so characteristic of *Iguanodon*, is wanting.

The remains of what I take to be the right fibula and tibia are seen in front of the pelvis. What remains of the fibula is 4 inches long, and shows the proximal end and moiety of the shaft tolerably entire. The former measures 0·7 inch from before backwards, but not more than 0·2 inch in width. The anterior edge of the shaft is turned towards the eye. An impression on the matrix is continued in the line of direction of the bone, and suggests that it was altogether about 5 inches long, and that its distal end had a width of 0·4 inch. In *Iguanodon*, the length of the tibia is to that of the femur as 31 to 33, and the fibula is somewhat shorter than the tibia. If *Hypsilophodon* followed the proportion of *Iguanodon*, the tibia should be 5·35 inches long, and the fibula rather more than 5 inches.

On reference to the memoir which I have cited, it will be observed that my interpretation of the bones described is very different from that adopted by Prof. Owen (p. 2). He terms the femur (65) "the right femur," and states that "the bones of the right hind leg are almost completed when the blocks containing their opposite ends are brought into juxtaposition." But the most cursory inspection is sufficient to show that the femur belongs to the left side, and, as I have proved, the so-called right tibia and fibula (66 and 67) are really the two ischia and the pubes.

I find myself compelled to dissent as widely from Prof. Owen's view of what he terms "the principal bones of the right hind foot." I have no sort of doubt it is the left hind foot. For there are two bones belonging to the distal tarsal series in their natural relation with one another, and with two, if not three, metatarsal bones. These bones are obviously the homologues of those which exist in *Scelidosaurus* and in the *Crocodilia*, and which lie on the outer side of the foot. The metatarsals which are connected with these bones,

therefore, must needs belong to the outer, or fibular, digits; and, as the dorsal surface of the metatarsus is turned towards the eye, the foot can only be that of the left limb. In the proximal row of the tarsus lie a calcaneum (which seems to have a process as in Crocodiles and an astragalus, with a convex distal face and seemingly flattened from above downwards. Whether it has an ascending process cannot be distinctly made out. The proximal and the distal series of bones are dislocated, and what looks like the end of the tibia is seen between and below them. The metatarsals of the first, second, and third digits are quite distinct; but the distal end is entire only in the first, or that of the hallux, which measures 1·85 inch in length. It has a pulley-shaped articular surface, and is 0·5 inch wide. The shaft of the bone is greatly compressed from side to side, as in *Scelidosaurus.* The second and third metatarsals are much broader and stouter, with flattened superior faces. They also seem to have been longer than the first. The fourth metatarsal looks, at first, as if it were much wider than the other; but, on close examination, I think I can trace a line of matrix separating a true fourth metatarsal, of about the same size as the others, from a slender fifth metatarsal. A basal phalanx, which seems to have belonged to the middle digit, is 1 inch long, 0·6 inch wide at the proximal, and 0·35 inch at the distal end. The pes of *Hypsilophodon*, thus, was either tetradactyle or pentadactyle.

The length of the trunk and tail of *Hypsilophodon* was probably about $4\frac{1}{2}$ feet; and, in all likelihood, it was mainly herbivorous.

EXPLANATION OF PLATES I. AND II. [PLATE 28].

PLATE I. [PLATE 28].

FIG. 1. The skull of *Hypsilophodon Foxii*, of the natural size.

Pa, parietal; *Fr*, frontal; *Na*, nasal; *Pmx*, præmaxilla; *La*, lacrymal; *Mn*. mandible; *a*, prælacrymal vacuity; *b*, suture between the præmaxillary and maxillary bones; *N*, nasal aperture; *c*, centrum of a vertebra.

2. A molar tooth, and

3. An incisor tooth, magnified.

4. The left ramus of the mandible: *Qu*, the quadrate bone; *a*, the coronoid process.

5. The left præmaxilla. In this figure and in fig. 1 the line from *Pmx* leads to the edentulous prolongation.

6. Side view of a caudal vertebra, of the size of nature.

7. End view of another caudal vertebra.

8. A chevron bone, of the natural size.

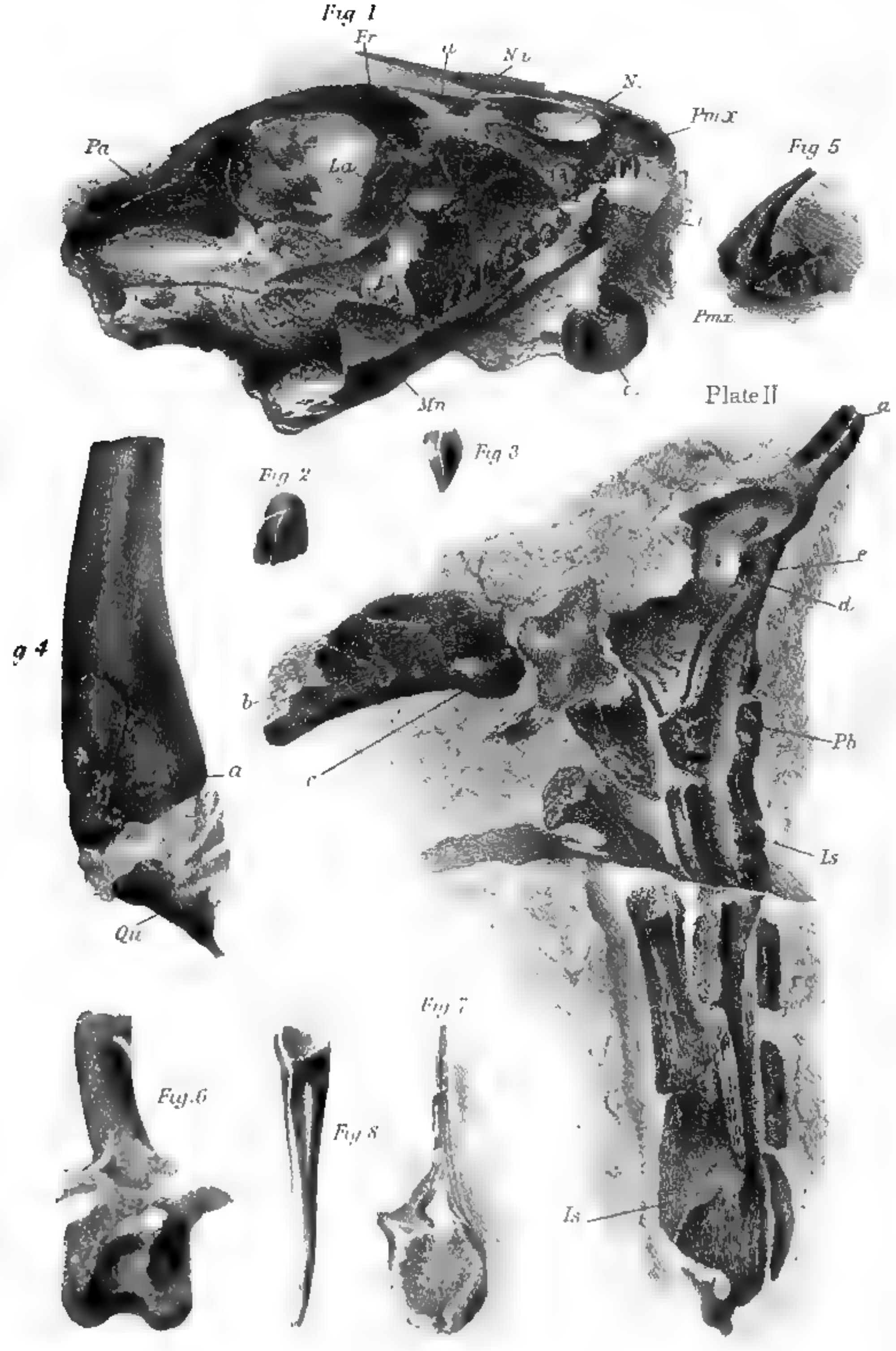
PLATE II. [PLATE 28].

The pelvis of *Hypsilophodon Foxii*, seven-twelfths ($\frac{7}{12}$) the natural size.

a, the anterior, *b*, the posterior extremity of the right ilium; *Is. Is.*, the right and left ischia; *Pb*, the pubis.

[PLATE 28.]

Quart. Journ. Geol. Soc. Vol. XXVI. Pl^{s} I & II.



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HYPSILOPHODON FOXII.

XXVIII

FURTHER EVIDENCE OF THE AFFINITY BETWEEN THE DINOSAURIAN REPTILES AND BIRDS.

The Quarterly Journal of the Geological Society of London, vol. xxvi., 1870, *pp.* 12–31. (*Read November* 10*th*, 1869.)

On my way to Birmingham, in October, 1867, I chanced to meet with Prof. Phillips; and mentioning some palæontological inquiries, chiefly relating to the Ichthyosauria (with which I then happened to be occupied), he very kindly urged me, as I returned to London, to pay a visit to the collection under his charge in the University Museum at Oxford. I did so; but as we were traversing the museum towards the Ichthyosaurian cases, we stopped at that containing the Megalosaurian remains, and I may say with Francesca—

"Quel giorno più non vi leggemmo avanti."

It is indeed a wonderful collection, ample enough to occupy the working hours of many a day; and it was particularly attractive to me, as some difficulties in the organization of *Megalosaurus* and its allies had long perplexed me.

As Prof. Phillips directed my attention to one after the other of the precious relics, my eye was suddenly caught by what I had never before seen, namely, the complete pectoral arch of the great reptile, consisting of a scapula and a coracoid ankylosed together. Here was a tangle at once unravelled. The coracoid was totally different from the bone described by Cuvier, and by all subsequent anatomists, under that name. What then was the latter bone? Clearly, if it did not belong to the shoulder-girdle it must form a part of the pelvis; and, in the pelvis, the ilium at once suggested itself as the only possible homologue. Comparison with skeletons of reptiles and of birds, close at hand, showed it to be not only an ilium, but an ilium which,

bones were *frequent* at Stonesfield and in the contemporaneous (geologically speaking) Oolitic beds of the vicinity, viz. *Megalosaurus* and *Teleosaurus.* To these must be added, as usually of somewhat later date, *Cetiosaurus* of Owen, and, still later, for the most part, *Steneosaurus.* *Teleosaurus* and *Steneosaurus* require *scrutiny* to be differentiated: the bones of *Cetiosaurus* in this collection are more easily separated from those of *Megalosaurus*; but there are not many homologous bones of these two reptiles in our collection, rich as it really is. I mention these things chiefly to satisfy you that, *exceptis excipiendis*, the large case which you saw filled with the reliquiæ of the great land Saurian contained no other than his personal remains.

"When the Stonesfield fossils came before me for lectures to a practical class, it was often my desire to present a sketch of the skeleton for comparison with that of a crocodile, and a pleasure to me to employ in this way such knowledge of the osteology of reptiles as a few dissections, now thirty or forty years ago, of each great reptilian group had fixed in my mind. For making these drawings on a large scale I was obliged to examine and consider several times the great bone called by Cuvier 'coracoid,' and to *complete* it by adding, after the pattern of *Varanus*, the extensions toward he sternum. When this was done, the magnitude of the thoracic region became such as to terrify me, and I looked eagerly through the collection for anything to relieve my alarm. Not being able to find any trace of sternal or episternal bones, I examined the curiously bent bone commonly referred to clavicle, and perceived that *it* was of the same order of magnitude. Next a set of spatulate bones, in fragments, came under my notice, and I speedily decided, *ex necessitate*, these to be scapulæ.[1] When completely restored they presented long flattened bones, concave on one broad face, convex on the other. I know no scapulæ like them except those of birds; and among birds none appeared to fit so well in the comparison as *Apteryx*. Then I reflected—a scapula like this, how could it belong to a coracoid like that? Examining for this purpose the humeral extremity of the bone, and collecting all the examples, I found it was composed of two elements ossified together, these elements concurring on one edge to form an articular cavity. Of these elements the broader and shorter one, which extended toward the sternum, was coracoidian in form, and perforated in each of four specimens. If,

[1] In his "Notice of *Megalosaurus*" (Brit. Assoc. Reports, 1841, p. 108), Professor Owen says, "The scapula is a thin, slightly bent plate, of equal breadth, except where it is expanded and thickened towards the humeral end, but thinning off again towards the articular margin."

attachment, on one face of the bone, such as might be left by the removal of cohering processes from the sacrum. To this I was reluctant to give weight for the same reason, viz. that it seemed to make *Megalosaurus* too 'sib' with primæval birds. In this state of mind you found me, and, to my surprise, took up *de novo*, and resolutely, to compare the bone with the pelvic arrangement of Ostrich and its congeners.[1] You also then seized upon the so-called 'clavicle,' and rapidly placed it in a probable manner to one of the tuberosities which project beyond the acetabular cavity, and called it an ischial or else a pubic bone, of struthious rather than lacertian analogy. Every observation which I have since been able to make goes to confirm this result, and the corollary from it, viz. a decided ornithic alliance of the pelvic, as we already found in the sternal, arrangement. Perhaps in the same direction may be cited the distinctly tubular character of the limb bones, which I have not perceived as yet in *Cetiosaurus*, though it may perhaps be found to be the case, and I think it will be.

"As you are now engaged in working out the true affinities of this uncommon creature, I propose to send you careful drawings of our most characteristic specimens, and will now only request your attention to one or two things which have occurred to my observation.

"These are two forms of the great pelvic (ilial) bone—the well-known ordinary form, which occurs in several examples, and another, in one quite young. The difference is very considerable, too great, I suppose, to be explained as a mark of age.

"There are two forms of scapula, both very large: the largest (one example) is separate from the coracoid; the others (several) are joined to the coracoid by synostosis. You will see the differences in the drawings. I am disposed to admit the larger specimens as belonging to *Cetiosaurus*, of which one huge femur (*Cetiosaurus giganteus*, Owen) was found in a deposit not much differing in age at Gibraltar, north of Oxford.

"We have several specimens of metatarsal bones from Stonesfield—Megalosaurian no doubt. Lately there came to hand three metatarsals from the Kimmeridge clay of Swindon, which appear also to be of the same reptile. These were in apposition, cemented by a thick crust of selenitic crystals. These have now been removed, and the bones appear clear.

[1] It appears that Buckland had suggested to Cuvier, but unsuccessfully, what now appears to be the right view; for we read, "Toutefois je ne puis guère douter que ce ne soit un coracoïdien de Saurien : il ressemble beaucoup moins à leur os des îles, auquel M. Buckland l'a comparé" (Oss. Foss. v. pl. 2, p. 346).

"It seems to me that these three bones the metatarsus, and that the creature was tr there may be reason not to trust too much t a negative. Still that seems to me the prob have plenty of information about the femur tarsals, and claw-bone, the reconstruction of practicable. But we want in this museum inf and anterior dorsal vertebræ, and the centr arrangements: of ribs we have sufficient exam short bicipital ribs, to very long arched wid the middle of the body, or, rather, a little be *Marsupialia* do not appear to me to offer an to any of the Megalosaurian bones. Amo furnish the most analogous forms, among bird

"Wishing you well through the Deinosaur

"Believe me, ever

On the 7th of February, 1868, I publish the studies to which Prof. Phillips gives his b "On the Animals which are most nearly Birds and Reptiles," delivered at the Royal quently published in the 'Proceedings' of th the addition of sundry illustrations, in the view.' But in this lecture I drew my illust structure almost wholly from *Iguanodon*. M that *Iguanodon* was the only typical *Dinos* remains of the greater part of the body of a associated together, while, at the same time, peculiarities of which can be clearly made out,

The conclusions at which I had at that enunciated.—

"The *Dinosauria*, a group of extinct r genera *Iguanodon*, *Hadrosaurus*, *Megalosaurus*, *saurus*, *Plateosaurus*, &c., which occur throug of the Mesozoic rocks, and are for the most appear to me to furnish the required condition

"In none of these animals are the skull or the vertebral column completely known, whil

[1] Professor Phillips has now (January, 1870) obtained a c smaller head than was calculated from the known portion of t

manus have not yet been obtained in any of the genera. In none has any trace of a clavicle been observed.

"With regard to the characters which have been positively determined, it has been ascertained that:—

"1. From four to six vertebræ enter into the composition of the sacrum, and become connected with the ilia in a manner which is partly ornithic, partly reptilian.

"2. The ilia are prolonged forwards, in front of the acetabulum, as well as behind it; and the resemblance to the bird's ilium thus produced is greatly increased by the widely arched form of the acetabular margin of the bone, and the extensive perforation of the floor of the acetabulum. The other two components of the *os innominatum* have not been observed actually in place; indeed, only one of them is known at all, but that one is exceedingly remarkable from its strongly ornithic character. It is the bone which has been called 'clavicle' in *Megalosaurus* and *Iguanodon* by Cuvier and his successors, though the sagacious Buckland had hinted its real nature.[1] But these bones are not in the least like the clavicles of any known animal, while they are extremely similar to the ischia of such a bird as an ostrich; and in the only instance in which they have been found in tolerably undisturbed relation with other parts of the skeleton, namely, in the Maidstone *Iguanodon*, they lie, one upon each side of the body, close to the ilia. I hold it to be certain that these bones belong to the pelvis, and not to the shoulder-girdle, and I think it probable that they are ischia; but I do not deny that they may be pubes.

"4. The head of the femur is set on at right angles to the shaft

[1] The so-called "coracoid" of *Megalosaurus* is the ilium. I am indebted to Prof. Phillips, and to the splendid collection of Megalosaurian remains which he has formed at Oxford, for most important evidence touching this reptile.

[I do not know how it came about that I have here confused Dr. Buckland's suggestions with one another. In his memoir "On the *Megalosaurus*" (Tr. Geol. Soc. 2nd ser. vol. ii. p. 396), Dr. Buckland says:—

"The bone represented in fig. 3 is the outside view of the ilium, slightly concave. The inner surface is slightly convex, and shows marks of articulation with the sacrum."

The bone in question is that of which Cuvier makes the remark quoted by Prof. Phillips.

All subsequent writers have followed Cuvier's determination, which was wrong, and ignored Buckland's, which was not only quite right, but the key to a great deal that is most important in Dinosaurian organization. The so-called "clavicle" was so named by Buckland himself. Cuvier hesitates to recognize it as such, inclining to the belief that it may be the fibula. According to Prof. Owen the presence of this clavicle is one of the chief features of the *Dinosauria*. "The chief marks of difference from the Crocodile structure of the scapular arch and of resemblance to the Lacertian type is the presence of a distinct pair of clavicles."—'Fossil Reptilia of the Wealden Formation,' p. 33.]

There is one part of the organization of the *Dinosauria* which is not mentioned in this enunciation, because I did not at that time see its bearing upon the problem under discussion. I mean the very singular structure of the distal moiety of the tibia.

It took me a great deal of trouble to comprehend the structure of this bone, the extant descriptions being very imperfect, and sometimes based upon bones which have been broken and put together the wrong way by the mender. In the British Museum collection the only thoroughly trustworthy *Iguanodon* tibia I can find is the small one numbered 36,403. It has been broken into several pieces; but they are very well fitted together, and the bone is not at all distorted. A second tibia of *Iguanodon*, with a very good proximal end, is numbered 28,669. The distal end of the Megalosaurian tibia (No. 31,809), which has been figured, is imperfect; but there was a tibia of *Megalosaurus* in the collection, the distal end of which was still inserted in its matrix; and, at my request, it was very carefully worked out. This tibia is the most perfect I have seen.

Its proximal end is produced into a great cnemial crest, which is concave on its outer, convex on its inner side. But when the backs of the condyles rest upon a plane surface, the outer edge of the crest does not project beyond the outer side of the bone. The inner and outer condyles of the proximal end are not very unequal, though the outer is the smaller. On the outer side of the proximal end of the bone there is a strong longitudinal ridge for the attachment of the fibula. The shaft of the bone is somewhat flattened from before backwards, and the distal end is still more flattened and expanded. Moreover the direction of its faces is quite different from that of the principal faces of the proximal end of the bone. These look inwards and outwards, supposing the condyle to rest upon a posterior plane surface. But the faces of the distal moiety of the tibia look forwards and outwards, and backwards and inwards, the plane of the distal end of the bone being nearly at right angles to that of the proximal end. The antero-external face of the distal end presented a somewhat smooth surface, apparently for the articulation of a bone; and this surface was bounded above and internally by a sharply defined edge, which terminated the face of the shaft of the bone. This edge at first passed outwards and backwards, and was convex downwards; but having reached the middle of the surface of the bone, it turns upwards and is lost at about $\frac{1}{8}$ the length of the tibia from its distal end. The distal articular surface is wider internally than externally, and its external moiety projects further than the internal, so that its inferior contour is oblique and slightly sinuated.

belongs to the fibula indicate a hind foot of very extraordinary structure.

"To understand its nature, it is necessary to conceive that the leg to which these bones belonged was much compressed from side to side, so as to be sharp behind, like the tarsus of a duck, instead of being flattened from before backwards, like that of the Crocodiles, and still more that of the Monitors. Bearing this conception in mind, the bone *a a*, figs. 34–36, has some similarity in form to the astragalus of the Crocodile; but one sees that the calcaneum must have been altogether posterior and very small.

"The articular face of the tibia is 0·14 metre long; its greatest width (0·04) is towards its anterior fourth, which is acutely angulated; posteriorly, the inner edge is undulated. A curved crest ascends obliquely along the inner face of the tibia, and articulates with the ascending and compressed process of the astragalus. In consequence of its compression, the form of this astragalus is so curious that it might be taken, at first sight, for the calcaneum of a mammal.

"Below, it presents a convex cylindrical surface; above, it is irregularly concave, to adjust itself to the sinuosities of the articular face of the tibia; from its inner edge, posteriorly, arises the compressed process of which I have spoken. The internal face is semilunar. Behind, it is truncated, presenting a little concave facet, which undoubtedly articulated with the calcaneum.

"The animal to which this lower part of a leg and this tarsus belonged cannot have been less than thirty-six feet long, supposing it to have nearly the same proportions as the Gavials. If it had the proportions of a Monitor, its length must have amounted to forty-six feet."

Now, on comparing the distal end of the tibia of *Megalosaurus* with that of Cuvier's Honfleur Saurian, it was quite obvious that the two were closely analogous, and that *Megalosaurus* must have had an astragalus very like that of the Honfleur reptile. Evidence confirmatory of this conclusion was derived from another quarter.

The 'Mémoires de la Société Linnéenne de Normandie' (tome vi. 1838) contain a very remarkable paper by M. Eudes Deslongchamps, "Sur le *Poikilopleuron Bucklandii*, grand Saurien Fossile intermédiaire entre les Crocodiles et les Lézards," discovered in a Caen-stone quarry. The remains of this animal indicate that it had a length of from 25 to 30 feet; and as teeth of *Megalosaurus Bucklandii* occur in the Caen stone, Deslongchamps is inclined to suspect that *Poikilopleuron* may be identical with *Megalosaurus*. Among the bones of his *Poikilopleuron*, Deslongchamps obtained

two astragali, the resemblance of which to Cuvier in the 'Ossemens Fossiles,' was exce applying one of these bones to the end of a previously considered to be a femur, he found distal end of the tibia, corresponding in all Cuvier's specimen from the Honfleur clays. just appreciation of the close affinity between *Megalosaurus* would have been immensely f acquainted with the true structure of the dist the latter reptile.

I had got thus far in February, 1868, and it the facts just mentioned that I included *Poiki* the *Dinosauria*, in the lecture which has been however, I had not seen the following notes Philadelphia, which are contained in the 'Proce of Natural Sciences of Philadelphia,' for December, 1867, and in the 'Proceedings o History Society' for June, 1869, and whicl additions to his previously published accou Megalosauroid *Lælaps*.

The similarity of Prof. Cope's general conc his second note, render it necessary for me to p not possibly have known anything about them delivered, still less at the time when the lette which I have cited, was written.

"E. D. Cope pointed out the anomalous rela the tibia and the fibula in certain of the *Dinos* the genus *Lælaps*. He remarked, the distal ex transverse and much compressed, and does n usual appearances of an articular surface, neithe nor a cotyloid cavity sufficient for an astragalus for an animal of such bulk. A bone presentin faced articular surface was discovered with the puzzled the anatomists who had seen it. This whole posterior aspect two faces, which form a fixed articulation; this is found to have been ap of the tibia exactly, and to have been fixed by ments. The medianly constricted condyle, pre little downwards, exhibits so little analogy witl suggest other interpretations; and after a ca seems evidently the distal extremity of the

furnishes a small articular surface at the knee, and fitting the tibia by the concavity of its inner face, becomes greatly attenuated at its distal third, where it is, in consequence of the obliquity of its direction, applied to the anterior face of the former bone. It then spreads into a plate extending to the inner margin of the tibia, while the solid shank is continued along the outer margin, and both terminate in the massive condyle, which embraces the whole extremity of the tibia like an epiphysis.

"One other example only of this structure is known in the Vertebrata, of which I only find mention in Cuvier, 'Ossemens Fossiles,' x. p. 204, tab. 249, figs. 34, 5. This author studied the distal extremity of a tibia, with applied fibula condyle, from Honfleur, which he was not able to assign to any known species or genus, but which he, with his usual sagacity, included in the chapter devoted to *Megalosaurus*. He however regarded the face of the tibia receiving the condyle-bearing bone as the inner instead of the anterior, stating that the tibia is laterally instead of antero-posteriorly compressed; so anomalous is this structure among Vertebrates. He regarded the bone as the astragalus, and did not perceive any connexion between its ascending apophysis and a fibula, partly because a fibula with distinct distal articulations was received with the same bones.

"The fibula condyle possesses an articular facet on its exterior extremity (anterior, Cuvier), probably adapted to a corresponding face of a calcaneum. Its plane is transverse, and does not cover the whole extremity, the anterior margin and a knob on the antero-superior part of the extremity projecting beyond it. Exterior to the middle of the upper margin of this piece, and at the internal base of the ascending apophysis, it is perforate, as is the cavity above the condyles of the humerus in the higher apes, and may have received a similar coronoid process of an astragalus.

"As compared with the species examined by Cuvier, this fibular condyle has a less elevated form; in Cuvier's specimen the ascending apophysis was flatter, broader, and directed towards the calcaneal facet instead of from it; it lacked the submedian perforation. Its tibial face appears to have been rounded, not angulate. The tibia presented an ascending ridge to the face by which the ascending apophysis was applied; in the *Lælaps aquilunguis* there is no ridge, the apophysis reposing in a slight concavity. This apophysis, like the slender portion of the fibula, is composed of dense bone . . . . .

"The direction of the condyle indicates the articulation of the tarsal elements to have been at a considerable angle with the shank

fibula, much resembling the structure of the foot of the chick of the ninth day, as given by Gegenbaur. The zygomatic arch was of a very light description. He was convinced that the most bird-like of the tracks of the Connecticut sandstone were made by a nearly allied genus, the *Bathygnathus* (Leidy). These creatures, no doubt, assumed a more or less erect position, and the weight of the viscera, &c., was supported by the slender and dense pubic bones, which were to some extent analogous to the marsupial bones of implacental Mammalia, though probably not homologous with them.

"He said he was satisfied that the so-called clavicles of *Iguanodon* and other *Dinosauria* were pubes, having a position similar to those of the *Crocodilia*—also that a species of *Lælaps* had been observed in France, by Cuvier, which was different from the *L. aquilunguis*, and which he proposed should be called *Lælaps gallicus*.

"*Compsognathus* (Wagner), type of the *Symphopoda*, expressed the characters of the latter in the entire union of the tibia and fibula with the first series of tarsal bones—a feature formerly supposed to belong to the class Aves alone, until pointed out by Gegenbaur. This genus also offered an approach to birds in the transverse direction of the pubes (unless this be due to distortion in the specimen figured by Wagner), their position being intermediate between the position in most reptiles and in birds. Other bird-like features were the great number and elongation of the vertebræ of the neck, and the very light construction of the arches and other bones of the head.

"He thought the Penguin, with its separated metatarsals, formed an approach on the side of the birds; but whether the closest approximation to the *Symphopoda* should be looked for here or among the long-tailed Ratitæ (Ostrich, &c.) he was unable to indicate."

The 'Proceedings of the Boston Natural History Society' for June 18th, 1869, state that Prof. Cope "gave an account of the discovery by Dr. Samuel Lockwood, of Keyport, of a fragment of a large Dinosaur, in the clay which immediately underlies the clay-marls below the lower Greensand bed in Monmouth County, New Jersey. The fossil represented the extremities of the tibia and fibula, with astragalo-calcaneum ankylosed to the former, in length about sixteen inches, distal width fourteen. The confluence of the first series of tarsal bones with each other and with the tibia he regarded as a most interesting peculiarity, and one only met with elsewhere in the reptile *Compsognathus* as in birds. He therefore referred the animal to the order *Symphopoda*, near to *Compsognathus*, Wagner.

acetabulum ; and the acetabulum is either wholly closed by bone, or presents only a moderate-sized fontanelle, as in the *Crocodilia*.

In the Bird the ilium is greatly prolonged in front of the acetabulum, and the roof of the acetabular cavity is a wide arch, the inner wall of that cavity remaining membranous. The anterior pier of the arch or præacetabular process extends further downwards than the posterior pier or postacetabular process.

Now, in all the *Dinosauria* which I have yet examined, the ilium extends far in front of the acetabulum, and furnishes only a widely arched roof to that cavity, as in Birds. It retains a reptilian character in the further proportional extension of the postacetabular process downwards.

2. The ischium in the Reptile is a moderately elongated bone, which becomes connected with the pubis in the acetabulum, and extends downwards, inwards, and somewhat backwards, to unite with its fellow in a median ventral symphysis. The obturator space is not interrupted by any forward process of the outer and anterior half of the ischium.

In all birds the ischium is elongated and inclined backwards, the backward direction being least marked in *Apteryx*, and most in *Rhea*. The ischia never come together directly in a median ventral symphysis, though they unite dorsally in *Rhea*. The anterior edge of the external half of the ischium very generally sends off a process which unites with the pubis, thus dividing the obturator space.

In all the *Dinosauria* in which I have been able to identify the bone (*Thecodontosaurus*, *Teratosaurus*, *Megalosaurus*, *Iguanodon*, *Stenopelyx*, *Hadrosaurus*, *Hypsilophodon*), the ischium is greatly elongated. In *Iguanodon* it has the *obturator* process characteristic of the same bone in birds; and I imagine that the same process is seen in *Compsognathus*. In *Hypsilophodon* there can be no mistake about the matter, and the remarkable slenderness and prolongation of the ischium gives it a wonderfully ornithic character. In *Iguanodon* this slenderness and prolongation are carried beyond what is to be seen in Birds. I am disposed to think, however, that, as was certainly the case in *Hypsilophodon*, the ischia united in a median ventral symphysis in all the *Dinosauria*.

Thus the ischia of a Dinosaurian are more bird-like than those of any existing reptile, but retain the reptilian union in a symphysis.

3. In all Reptiles the pubis is inclined forwards as well as downwards towards the ventral median line. In all except the Crocodile it takes a considerable share in the formation of the acetabulum; and in all, except the Crocodile again, the ossified pubis unites

cess of the astragalus, with a fragment of its bony substance, exactly where it should be. With this complete knowledge of the tibia, fibula, and astragalus of such a typical Dinosaurian as

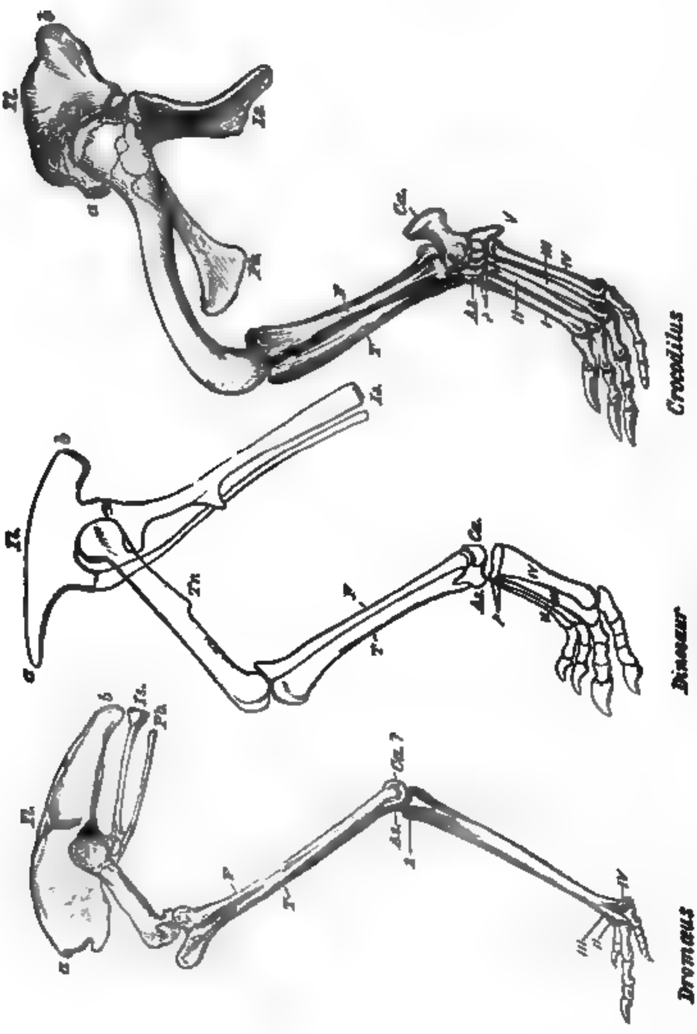


FIG. 3. The pelvis and hind limb of an Emu (*Dromaeus*) and a Crocodile (*Crocodilus*), for comparison with the diagrammatic restoration of the corresponding parts in an Iguanodontoid Dinosaurian. The bones of the Bird are in their natural position; in the Dinosaur it may be a question whether the metatarsus was so much raised; in the Crocodile the foot would naturally be flat upon the ground, and the thigh turned out nearly at right angles to the body. The letters have the same signification throughout: *Il*, ilium; *a*, *b*, its anterior and posterior extremities; *Is*, ischium, *Pb*, pubis; *Tr*, trochanter of the femur of the Dinosaur; *T*, tibia; *F*, fibula; *As*, astragalus; *Ca*, Calcaneum; 1, the distal division of the tarsus; I, II, III, IV, V, the digits.

Megalosaurus, let us compare these bones with the corresponding bones of Reptiles and Birds, as we have compared the pelvis.

In Reptiles (ordinary *Lacertilia* and *Crocodilia*, namely, which are alone at present under consideration),—

1. The proximal end of the tibia has but a very small or quite

rudimentary cnemial crest, and it presents no ridge for the fibula on its outer side.

2. The flattened sides of the distal end of the tibia look, the one directly forwards, or forwards and inwards; and the other backwards, or backwards and outwards. And when the posterior edges of the two condyles of the proximal ends of the tibia rest on a flat surface which looks forwards, the long axis of the distal end is either nearly parallel with that surface, or is inclined obliquely from in front and without backwards and inwards.

3. There is no depression in the anterior face of the tibia for the reception of an ascending process of the astragalus.

4. The distal end of the fibula is as large as, or larger than, the proximal end, and articulates largely with a facet on the outer part of the astragalus.

5. The astragalus is not depressed and flattened from above downwards, nor does it send a process upwards in front of the tibia.

6. The astragalus remains quite free from the tibia.

In all these respects any ordinary bird, say a fowl, is very strikingly contrasted with the reptile.

1. The proximal end of the tibia is produced forwards and outwards into an enormous cnemial crest; and, on the outer side, there is a strong ridge for the fibula.

2. When the posterior edges of the condyles of the tibia rest upon a flat surface, the one flat surface of the distal end of the bone looks outwards as well as forwards, and the other inwards as well as backwards, and the axis of the distal end is inclined at an angle of 45° to the flat surface from within and in front, backwards and outwards, thus exactly reversing the direction in the Reptile.

3. There is a deep longitudinal depression on the anterior face of the distal end of the tibia, which receives an ascending process of the astragalus.

4. The distal end of the fibula is a mere style, and does not directly articulate with the astragalus.

5. The astragalus is a much-depressed bone, with a concave proximal and a convex, pulley-like distal surface. A process ascends from its front margin in the groove in the front face of the tibia. This process is comparatively short, and perforated by two canals for the *tibialis anticus* and *extensor communis* in the Fowl, while in the Ostrich and Emu it is extremely long and not so perforated.

6. The astragalus becomes ankylosed with the tibia (though it remains distinct for a long time in the Ostrich and *Rhea*, and in some breeds of fowls).

Now in every one of these particulars, except perhaps the last, *Megalosaurus* is far more like a bird than it is like a reptile.

1. There is a great cnemial crest and a ridge for the fibula.

2. The disposition of the distal end of the tibia is literally that observed in the bird.

3. There is a fossa for the reception of the ascending process of the astragalus.

4. The distal end of the fibula is much smaller than the proximal, though not so slender as in *Aves*. It cannot articulate with the astragalus in the precise way observed in Reptiles.

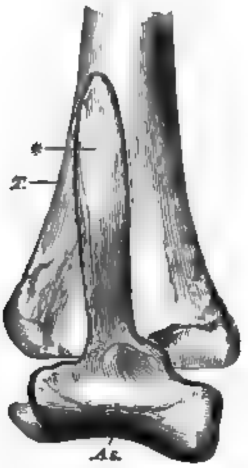


FIG. 4, front view.

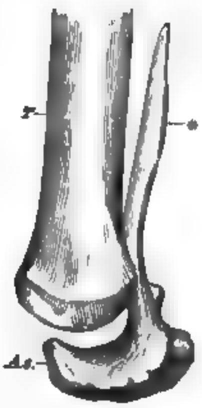


FIG. 5, side view.

The distal end of the tibia (*T*), with the astragalus (*As*), of a young Ostrich in the Museum of the Royal College of Surgeons. * The ascending process of the astragalus.

5. The astragalus is altogether similar to that of a bird, with a short ascending process. I suspect that the perforation observed in this process in *Lælaps* by Prof. Cope, is the opening of a canal or canals for tendons, as in the fowl.

6. The astragalus appears to have remained distinct from the tibia throughout life in *Megalosaurus*; but it seems to have become ankylosed in *Compsognathus*, and Prof. Cope describes it as ankylosed in *Ornithotarsus*. I believe I have evidence of the same coalescence in *Euskelosaurus*.

I find that the tibia and the astragalus of a Dorking fowl remain readily separable at the time at which these birds are usually brought to table. The cnemial epiphysis is also easily detached at this time.

If the tibia without that epiphysis and the astragalus were found in the fossil state, I know not by what test they could be distinguished from the bones of a Dinosaurian. And if the whole hind quarters, from the ilium to the toes, of a half-hatched chicken could be suddenly enlarged, ossified, and fossilized as they are, they would furnish us with the last step of the transition between Birds and Reptiles; for there would be nothing in their characters to prevent us from referring them to the *Dinosauria*.

DISCUSSION.

Sir RODERICK MURCHISON, who had taken the Chair, inquired as to the habits of the *Hypsilophodon*.

Mr. HULKE mentioned that Mr. Fox had two blocks containing remains of a large portion of the *Hypsilophodon*, all procured from a thin band of sandstone near Cowleaze Chine. On one the pelvis is almost entire, as well as the right femur, the tibia (which is longer than the femur), four long metatarsal bones, and an astragalus. All the long bones are hollow. Portions of at least eight individuals have been found in the same bed.

Mr. SEELEY doubted whether these animals should be called Reptiles at all, as they seemed to him to form a group distinct alike from reptiles, birds, and mammals, but occupying an intermediate position. In the hinder limbs of *Pterodactylus* the analogies were closer with mammals than with birds. He thought it possible that the peculiar structure of the hinder limbs of the Dinosauria was due to the functions they performed, rather than to any actual affinity with birds.

The PRESIDENT, in reply, stated that *Hypsilophodon*, from the character of its teeth, probably subsisted on hard vegetable food. He expressed a hope that Mr. Fox would allow a closer examination of his specimens to be made. He was unable to agree with Mr. Seeley's views. He was inclined to think that the progress of knowledge tended rather to break down the lines of demarcation between groups supposed to be distinct than to authorize the creation of fresh divisions.

XXIX

ON THE CLASSIFICATION OF THE DINOSAURIA WITH OBSERVATIONS ON THE DINOSAURIA OF THE TRIAS.

The Quarterly Journal of the Geological Society of London, vol. xxvi., 1870, *pp.* 32–50. (*Read November 24th*, 1869.)

PLATE III. [PLATE 29].

I. THE CLASSIFICATION AND AFFINITIES OF THE DINOSAURIA

CONTENTS.

1. The history and definition of the group.
2. The establishment of the order *Ornithoscelida* to include the *Dinosauria* and the *Compsognatha*.
3. The affinities of the *Ornithoscelida* with other Reptiles.
4. The affinities of the *Ornithoscelida* with Birds.

1. *The History and Definition of the Group.*

THE recognition of what are now commonly termed the *Dinosauria*, as a peculiar group of the *Reptilia*, is due to that remarkable man whose recent death all who are interested in the progress of sound palæontology must deplore—Hermann von Meyer. In his 'Palæologica,' published so long ago as 1832,[1] Von Meyer classifies fossil reptiles according to the nature of their locomotive organs; and his second division, defined as "Saurians, with limbs like those of the heavy terrestrial Mammalia," is established for *Megalosaurus* and *Iguanodon*. To this group Von Meyer subsequently applied the name of *Pachypodes* or *Pachypoda*.

Nine years afterwards Professor Owen, in his "Report on British

[1] Von Meyer refers to the 'Isis' for 1830, as containing the first sketch of his views. I have not verified the citation.

Fossil Reptilia," conferred a new name upon the group, and attempted to give it a closer definition, in the following passages :—

"*Dinosaurians.*—This group, which includes at least three well-established genera of Saurians, is characterized by a large sacrum composed of five ankylosed vertebræ of unusual construction, by the height and breadth and outward sculpturing of the neural arches of the dorsal vertebræ, by the twofold articulation of the ribs to the vertebræ, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only; by broad and sometimes complicated coracoids and long and slender clavicles, whereby Crocodilian characters of the vertebral column are combined with a Lacertian type of the pectoral arch; the dental organs also exhibit the same transitional or annectent characters in a greater or less degree. The bones of the extremities are of a large proportional size for Saurians; they are provided with large medullary cavities and with well-developed and unusual processes, and are terminated by metacarpal metatarsal, and phalangeal bones which, with the exception of the ungual phalanges, more or less resemble those of the heavy pachydermal mammals, and attest, with the hollow long bones, the terrestrial habits of the species.

"The combination of such characters, some, as the sacral ones altogether peculiar among reptiles, others borrowed, as it were, from groups now distinct from each other, and also manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe, or suborder, of Saurian reptiles, for which I would propose the name of *Dinosauria*.

"Of this tribe the principal and best-established genera are the *Megalosaurus*, the *Hylæosaurus*, and the *Iguanodon*, the gigantic crocodile lizards of the dry land, the peculiarities of the osteological structure of which distinguish them as clearly from the modern terrestrial and amphibious *Sauria* as the opposite modifications for an aquatic life characterize the extinct *Enaliosauria*, or marine lizards."[1]

Further on it is stated that "the Reptilian type of structure made the nearest approach to mammals" in the *Dinosauria* (*l. c.* p. 202).

Every character which is here added to Von Meyer's diagnosis and description of his *Pachypoda* has failed to stand the test of critical investigation; while it is to birds and not to mammals that the *Dinosauria* approach so closely. There is, in fact, not a single specially mammalian feature in their whole organization.

[1] Prof. Owen's "Report on British Fossil Reptiles," 1841.

Even in point of etymological appropriateness, the term "*Dinosauria*" is no more fitting for reptiles of which some are small, than "*Pachypoda*" is for reptiles of which some have slender feet; but as Von Meyer's name has never obtained much currency, it may be well to allow justice to give way to expediency, and to retain the name of *Dinosauria* for those reptiles which agree in all the most important and characteristic parts of their structure with *Megalosaurus* and *Iguanodon*.

The group thus limited is susceptible of very clear diagnosis from all other reptiles, inasmuch as its members present the following combination of characters:—

1. The dorsal vertebræ have amphicœlous or opisthocœlous centra. They are provided with capitular and tubercular transverse processes, the latter being much the longer.

2. The number of the vertebræ which enter into the sacrum does not fall below two, and may be as many as six.

3. The chevron bones are attached intervertebrally, and their rami are united at their vertebral ends by a bar of bone.

4. The anterior vertebral ribs have distinct capitula and tubercula.

5. The skull is modelled upon the Lacertilian, not on the Crocodilian type. There is a bony sclerotic ring.

6. The teeth are not ankylosed to the jaws, and may be lodged in distinct sockets. They appear to be present only in the præmaxillæ, maxillæ, and dentary portions of the mandible.

7. The scapula is vertically elongated; the coracoid is short, and has a rounded and undivided margin. There is no clavicle.

8. The crest of the ilium is prolonged both in front of and behind the acetabulum; and the part which roofs over the latter cavity forms a wide arch, the inner wall of the acetabulum having been formed by membrane, as in birds.

9. The ischium and pubis are much elongated.

10. The femur has a strong inner trochanter; and there is a crest on the ventral face of the outer condyle, which passes between the tibia and the fibula, as in birds.

11. The tibia is shorter than the femur. Its proximal end is produced anteriorly into a strong crest, which is bent outwardly, or towards the fibular side.

12. The astragalus is like that of a bird; and the digits of the pes are terminated by strong and curved ungual phalanges.

The *Dinosauria* about which we have sufficient information appear to me to fall into three natural groups—i. the *Megalosauridæ*, ii. the *Scelidosauridæ*, and iii. the *Iguanodontidæ*.

i. The *Megalosauridæ.*

1. The maxillary teeth are sharp-pointed, longitudinal serrated ridge, either on the n face only, or on the middle of its anterio serrations of the ridge are directed at right a of the tooth. The teeth do not become worr

2. The anterior prolongation of the ilium or larger than, the posterior.

3. The rami of the mandible are deep an rounded ends in the symphysis.

4. The proximal end of the femur is fl twisted in such a manner that its plane is o flat surface on which the condyles rest. In c or less crocodilian.

5. There is no dermal armour.

Teratosaurus, Palæosaurus, Megalosaurus, and probably *Euskelosaurus* belong to this grou

ii. The *Scelidosauridæ.*

1. The maxillary and mandibular teeth ha gular crowns, with serrated margins, the serrat or parallel with, the long axis of the tooth worn down by mastication.

2. The anterior prolongation of the ilium the posterior.

3. The rami of the mandible are slender, symphysis.

4. The proximal end of the femur has a head, borne by a neck which is set nearly a axis of the shaft, while its direction is nearly surface on which the condyles rest.

5. The integument is (usually) provided w in the form of bony scales or spines.

Thecodontosaurus, Hylæosaurus, Polacanthus belong to this division.

iii. The *Iguanodontidæ.*

1. The maxillary and mandibular teeth hav crowns; the surface of the enamel being ridgec The crowns of the teeth are worn down flat by

2. The anterior prolongation of the ilium is more slender than the posterior.

3. The rami of the mandible unite in an excavated edentulous symphysis, which receives an edentulous prolongation of the præmaxillæ.

4. The proximal end of the femur is as in the *Scelidosauridæ*.

5. There is no dermal armour.

Cetiosaurus,[1] *Iguanodon*, *Hypsilophodon*, *Hadrosaurus*, and probably *Stenopelyx*[2] belong to this division.

These three groups appear to me to be very well marked; but I do not propose them with the intention of suggesting that there are no others, or that the progress of discovery will leave them thus well defined.

The very remarkable reptile, *Compsognathus longipes*, has many affinities with the *Megalosauridæ*, *Scelidosauridæ*, and *Iguanodontidæ*, but it presents, at the same time, so many differences from all these, and so much of its structure is left unrevealed by the solitary specimen which exists, that perhaps the most convenient course which can be adopted, at present, is to make it the representative of a group equivalent to them. *Compsognathus* differs from all the preceding forms in the length of the cervical relatively to the thoracic vertebræ, and in the femur being considerably shorter than the tibia.[3]

2. *Establishment of the Order* ORNITHOSCELIDA *to include the* Dinosauria *and the* Compsognatha.

But *Compsognathus* agrees with the *Megalosauridæ*, *Scelidosauridæ*, and *Iguanodontidæ* in the ornithic modification of the Saurian type,

[1] I assign this place to *Cetiosaurus* on the evidence of the splendid series of remains of this reptile which Prof. Phillips showed me in the Oxford Museum.

[2] Von Meyer has described a reptile from the German Wealden, in the 'Palæontographica' for 1859, under the name of *Stenopelyx Valdensis*. Only the pelvis, a few vertebræ, and the left hind limb of this very interesting genus are preserved; but they suffice to prove it to be a Dinosaurian. There are four digits in the foot, the fifth being absent, while the hallux is smaller than the others. The fibula is slender; the tibia stout and apparently as long as the femur, the head of which is at right angles with the shaft. The ischia are in place and longer than the femur; they are stouter in proportion than in *Iguanodon* or *Hypsilophodon*, and quite differently formed. What Von Meyer regards as the pubes, are, if I mistake not, the anterior prolongations of the ilia.

From the absence of any dermal armour one would be disposed to arrange *Stenopelyx* among the *Iguanodontidæ*; but many of its characters are very peculiar.

[3] Professor Cope has distinguished *Compsognathus* as the type of a division, *Ornithopoda*, from the rest of the Dinosauria, which he terms *Goniopoda*. The *Ornithopoda* have the astragalus ankylosed, while in the *Goniopoda* it is free. But there is much reason to believe that the astragalus became ankylosed in some of the "Goniopoda;" and it seems to me precisely by the structure of the foot that *Compsognathus* is united with, instead of being separated from, the *Ornithoscelida*.

which is especially expressed in the hind limbs; and I theref[ore] propose to unite it with them in one group, which I shall ter[m] ORNITHOSCELIDA. This group will contain two primary subdivision[s] —I. The *Dinosauria*, with the cervical vertebræ relatively sh[ort] and the femur as long as, or longer than the tibia. II. The *Com[p]sognatha*, with the cervical vertebræ relatively long, and the fem[ur] shorter than the tibia.

3. *The affinities of the* ORNITHOSCELIDA *with other Reptiles.*

If we consider the relations of the *Ornithosauria* to other rep[tiles], it is at once obvious that they belong to that great divisi[on] of the class in which the thoracic vertebræ have distinct capitul[ar] and tubercular processes, the latter being longer than the forme[r] and springing from the arch of the vertebræ, as in the crocodile. These reptiles may be termed *Suchospondylia*, to distinguish the[m] from another great group, in which the thoracic vertebræ have t[he] capitular and tubercular processes fused together into one proce[ss] or facet, and which may be termed the *Erpetospondylia*,—from [a] third, in which the capitular and tubercular processes are both me[re] tubercles springing from the centrum of the thoracic vertebr[æ], *Perospondylia*,—and from a fourth, *Pleurospondylia*, in which t[he] thoracic vertebræ have neither capitular nor tubercular transver[se] processes, but the ribs are sessile upon, and fixed to, the vertebræ.

The last-named group consists of the *Chelonia*; the *Perospondy[lia]* contain only the *Ichthyosauria*; the *Erpetospondylia* comprise t[he] *Ophidia*, *Lacertilia*, and *Plesiosauria*; while the *Suchospondyl[ia]* embrace the *Crocodilia*, the *Dicynodontia*, the *Pterosauria*, and t[he] *Ornithoscelida*.

The closest relations of the *Ornithoscelida* within this group a[re] with the *Dicynodontia* on the one hand, and the *Crocodilia* on t[he] other. The sacrum and the iliac bones of the Dicynodonts mo[re] closely resemble the corresponding parts of the *Ornithoscelida* th[an] they do those of any other *Reptilia*, except the *Pterosauria*[1]; an[d] there are a good many points of resemblance in the skull an[d] dentition. Our knowledge of *Rhopalodon* and of *Galesaurus* is hardl[y] sufficient to afford grounds for a safe opinion; but it seems probab[le] that they will turn out to be annectent forms between the *Dicyn[o]dontia* and the *Ornithoscelida*.

The connection of the *Crocodilia* with the *Ornithoscelida* [is] probably to be sought in some common form, more Lacertilian i[n]

[1] The complete occlusion of the obturator foramen by bone occurs in both the *Dicyn[o]dontia* and the *Pterosauria*, and in these alone among Reptiles.

its character than any of the known members of either of these groups. The oldest known Crocodilians, Belodon and its congeners, exhibit modifications which approximate them rather to the *Lacertilia* than to the *Ornithoscelida*.

If we seek for reptilian allies of the *Ornithoscelida* in formations of older date than the Trias, the Permian forms alone present themselves. Our knowledge of these is almost entirely due to the researches of Von Meyer, the results of whose investigations have hardly received the attention they deserve. They prove the existence of two very distinct reptilian genera, *Proterosaurus*[1] and *Parasaurus*, in the Kupferschiefer, and two others, *Phanerosaurus* and *Sphenosaurus*, different from them and from one another, in the Rothliegende, in which formation also a peculiar Labyrinthodont, *Osteophorus*, occurs.

Proterosaurus appears to me to be a true Lacertilian. At least, neither in Von Meyer's figures and descriptions, nor in the one classical specimen which exists in this country, can I find evidence of any essential departure from the old Lacertilian plan of structure, such as is exhibited by *Hyperodapedon* or *Telerpeton*—though it must be confessed that the long neck, light head, and short fore-limbs, to say nothing of the opisthotonic death-spasm which has left the fossils in their present position, remind one curiously of *Compsognathus*.

Parasaurus has four ankylosed sacral vertebræ, with great sacral ribs; and perhaps the two vertebræ which succeed these must be counted as sacral. It would appear from the figures, that the anterior ribs may have been, and probably were, divided into a distinct capitulum and a tuberculum. From the position of the undisturbed femora in one specimen, it cannot be doubted that the ilia must have extended a long way in front of the acetabulum. The length of the short and stout femur does not exceed that of four conjoined vertebræ; and there is some reason to think that the bones of the leg were considerably longer than the femur.

Parasaurus therefore belongs to a totally different group of reptiles from *Proterosaurus*, and I can compare it with nothing but the *Ornithoscelida* and the *Dicynodontia*.

The structure of both *Proterosaurus* and *Parasaurus* leads to the belief that they were terrestrial reptiles; and their occurrence in the Kupferschiefer is no bar to this conclusion, as land-plants abound in that rock.

The *Phanerosaurus* of the Rothliegende is based upon a series of half-a-dozen vertebræ, the characters of which are altogether peculiar.

[1] The generic distinctness of *Aphelosaurus* of Gervais appears to me to be doubtful.

Finally, with regard to the sternum, although there is no likelihood that the *Ornithoscelida* possessed a crested sternum, yet there is some evidence that they were provided with a very broad and expanded breast-bone, more like that of a bird than it is like that of any reptile. I shall discuss this evidence below, in speaking of the Dinosaurian remains discovered by Plieninger in the Trias near Stuttgart.

II. THE DINOSAURIA OF THE TRIAS.

CONTENTS.

1. DINOSAURIA *from the Trias of Germany and Central Europe.*

The first recognition of the occurrence in the Trias of Dinosaurian remains as such, with which I am acquainted, is contained in the following extract from a letter, addressed by H. Von Meyer to Bronn, and published in the 'Jahrbuch' for 1857.

"Dr. Engelhardt, of Nuremberg, brought to the meeting of Naturalists in Stuttgart some bones of a gigantic animal from a brecciated sandstone of the Upper Keuper of his neighbourhood. He had the kindness to submit to me all the bones which had been obtained. I have already examined them, and have drawn the best, which consisted of almost entire limb-bones and of vertebræ.

"The discovery is extremely interesting. The bones belong to a gigantic Saurian, which, in virtue of the mass and hollowness of its limb-bones, is allied to *Iguanodon* and to *Megalosaurus*, and will belong to the second division of my Saurian system. None of its allies has hitherto been found so deep in the European continent, nor from rocks of so great age. These remains belong to a new genus, which I term *Plateosaurus*: the species is *Pl. Engelhardtii.* I shall hereafter publish a full account of the fossils."

The fuller account which Von Meyer promises is contained in that splendid monument of palæontological genius and industry, the 'Saurier des Muschelkalkes,' which came out between 1847 and 1855. The remains enumerated consist of a few imperfect fragments of a cranium without jaws or teeth, six more or less fragmentary separate vertebræ, an imperfect sacrum (consisting of, at fewest, three ankylosed vertebræ), fragments of ribs, and several limb-bones. The

great size, which were discovered near Stuttgart, in the "red Keuper marl" which forms the uppermost part of the Trias in that region. One of these skeletons was discovered by Herr Reiniger, the other by Prof. Plieninger himself. Both were in a much shattered condition, and were devoid of the skull. The remains of the first skeleton, which I shall call A, comprised, according to Prof. Plieninger, sixty, more or less complete, successive vertebræ, the pelvis, the hind legs down to the phalanges, the humeri, a great number of fragments of ribs, the sternum, and thirteen isolated crowns of teeth, some entire digits, and separate phalanges. Of these, Plieninger figures what he describes as the best-preserved teeth and digital bones—the right and left humeri, with attached fragments of the ulna and radius and of the shoulder-girdle, the left femur, the left tibia, with attached fragments of the fibula and the right tibia, and a massive bone, the nature of which is doubtful.

The remains of the second skeleton (B) include what Prof. Plieninger determines as :—the entire pelvis, the ilia being separated from the sacrum, which consists of three bones, two only of which are ankylosed; a femur; an ischium; a few bones of the feet; the two scapulæ; one perfect humerus, and the other pathologically deformed; together with the eight vertebræ which preceded the sacrum, with all their processes entire, and in their natural relations to one another and the sacrum.

All these remains were found together. At four feet distance on the same level, and continuing the direction of the vertebral column, was a second series of seven vertebræ, five and two of them being respectively associated together. No remains of any other animal, or any other individual, were found along with these two skeletons, which clearly appertain to the same species. The evidence which they afford as to the nature of the reptiles to which they belonged, is therefore of very great value. This evidence has already been discussed by Von Meyer (*l. c.* p. 268), who concludes that the skeletons are not referable to *Belodon*, and judges, from "a certain resemblance to the corresponding parts of *Megalosaurus Bucklandi*," that they might have belonged to a Pachypode, and possibly to *Teratosaurus*, a reptile from the same locality and bed, the jaw of which he describes.

In this view I entirely concur. In fact, Plieninger's figures (which do not quite deserve the reproaches with which Von Meyer visits them) prove that the skeletons A & B belong to *Dinosauria*. But they also seem to me to show that one or two of Plieninger's determinations are erroneous. Thus, the two vertebræ of B, represented

half that width, with edges which vary from one to three inches in thickness. The anterior external angles are prolonged into stout processes, which are directed upwards and inwards and are somewhat recurved. Professor Plieninger considers this bone to be the sternum; and I see no reason for dissenting from his interpretation. A *Rhea* of the same size as the Triassic Dinosaurian would present a sternum of very similar proportions, especially as regards the antero-lateral or *pleurosteal* processes.

The scapular of B has a length of 21 inches. It is long and narrow. The coracoid is short and rounded, as in other *Dinosauria*. The humerus of A is rather more than 17 inches long; but that of B must have been 20 in. long, if the drawing is correct. Probably, therefore, B was a larger animal, and the length of the shoulder-bones of A must be proportionally reduced. The femur of A is 27½ in. long; the tibia about 20 in. long. The ilium of B seems to have been not less than 16 in. long.

In the Maidstone *Iguanodon*, the scapula is 29 in., the humerus is 19 in., the femur 33 in., the tibia 31 in., the ilium 30 in. long; so that the hind limbs were much longer in proportion to the fore limbs, the tibia in proportion to the femur, and the scapula in proportion to the humerus than in the Stuttgart Dinosaurian. The hinder dorsal vertebræ have centra rather less than 4 in. long, and fully 4 in. high, whence *Iguanodon* would seem to have possessed a shorter trunk in relation to its limbs.

The associated remains of a *Megalosaurus* which Mr. James Parker, of Oxford, was good enough to show me some time ago has ilia which are 26 inches long, femora 32 inches; and the tibiæ could not have been much shorter than the femora. *Scelidosaurus* has the ilium 16 inches long, the femur 16–17 inches, the tibia 13 inches, the scapula 13 inches, the humerus 11·25 inches. The length of a dorsal vertebra is 2⅛–2½ inches. Thus, in the proportions of the tibia to the femur and of the humerus to the femur, the Triassic reptile comes nearer to the Liassic *Scelidosaurus* than any other Dinosaurian; but the limbs are shorter in proportion to the vertebræ than they are even in *Scelidosaurus*.

The facts now detailed show that, as I have already hinted, for the last ten years ample evidence of the existence of at least two genera of *Dinosauria* in the German Trias has been in existence.

But in 1861 Von Meyer described and founded the genus *Teratosaurus* upon a left maxilla with teeth, which he declared to be distinct from *Belodon*, and to have, in all probability, belonged to Plieninger's Pachypode. This sagacious suggestion receives the strongest support

founded the genus *Thecodontosaurus* upon an imperfect mandible, containing twenty-one teeth (which was apparently the total original number) in a series. These teeth, they say, are acutely pointed and flattened, and the anterior edge is curved backwards and serrated; the posterior edge is also slightly curved and strongly serrated, the serratures being directed towards the apex of the tooth. The middle teeth are the largest; and all the teeth possess a conical pulp-cavity Pl. III. [Plate 29], figs. 1 & 2). To a single specimen of a broadly lanceolate tooth, with serrations at right angles to the axis, they attach the name of *Palæosaurus platyodon*. Another solitary tooth of more elongated conical form they term *Palæosaurus cylindrodon*. The description of the teeth of *Thecodontosaurus* is perfectly accurate; but I can see no important difference, in the direction of the serrations or otherwise, between these and the tooth called *Palæosaurus platyodon*, which, I suspect, may belong simply to a larger *Thecodontosaurus*.

In the tooth termed *Palæosaurus cylindrodon*, on the other hand, the direction of the serrations is really at right angles to the axis of the tooth; and in its form, also, the tooth more resembles that of *Megalosaurus*, being elongated, with the posterior margin straight or slightly concave, while the anterior contour is convex. The sharp posterior median ridge of the tooth extends for the whole length of the crown, and is strongly serrated throughout. The anterior serrated ridge is visible in what remains of the upper part of the crown; but I am unable to trace it in the lower half of the front face of the enamel (Pl. III. [Plate 29], fig. 3). I think it will be proper to restrict the name *Palæosaurus* to the latter (or Megalosauroid) form of tooth, and to use *Thecodontosaurus* for the former (or Scelidosauroid) type, the varieties of which may be embraced under the common name of *platyodon*.

The bones referred to and described by Riley and Stutchbury are vertebræ, ribs of two kinds, a clavicle, two "coracoids," a humerus, a "radius," two femora, an "ischium," a tibia, a fibula, metacarpal and metatarsal bones, and ungual phalanges.

The "coracoid" figured is, as I suspected, a fragmentary ilium. The "radius" I take to be a tibia. The parts of the skeleton which diagnose the Dinosaurian nature of these reptiles, in addition to the teeth, are:—1, a caudal vertebra with the chevron bone; 2, an ilium; 3, a tibia.

The diagnostic mark in the first part of the skeleton mentioned lies in the complete union of the crura of the chevron bones at their proximal ends, in consequence of which coalescence the fork of the

belonging to *Thecodontosaurus*. But, on the other hand, the teeth of *Thecodontosaurus* are Scelidosaurian in character; and it seems to be hardly likely that these teeth should have accompanied hind limbs which are the reverse of Scelidosaurian, and exaggerate the peculiarities of those of *Megalosaurus*, when we have, in *Palæosaurus*, a tooth so like that of *Megalosaurus* that it is only distinguishable by critical examination. With the present materials I do not think any decision can be safely arrived at on this question, and I shall speak of the bones as those of Thecodontosaurians, without prejudice as to the particular genus to which they may belong.

I may observe, in conclusion, that the ilium is shorter in proportion to the femur in these Dinosauria than in any others with which I am acquainted, and that the cavities in the bones are so extraordinarily large and well-defined that, if found alone, it would be hard to distinguish some of them from those of *Pterosauria*.

The Thecodontosaurians, then, are *Dinosauria*; but the question may be raised whether the conglomerate in which they are found is really Triassic, some geologists appearing to be inclined to think them of Rhætic age, while Von Meyer, as has been seen, looks upon them as transitional between Muschelkalk and Keuper.[1] It does not lie within my province to discuss this problem, the decision of which, either way, will not affect the occurrence of Dinosauria in the Trias; and I therefore pass on to examine into what evidence there may be of the existence of Dinosaurian reptiles in the Warwickshire sandstones, the Triassic age of which appears to be beyond question.

Many years ago certain teeth were discovered in these sandstones by Dr. Lloyd, and were placed by him in the hands of Professor Owen, who has thus described them in his "Odontography," which was published between the years 1841 and 1845:—

"In their compressed form, anterior and posterior serrated edges, sharp points, and microscopic structure, these teeth agree with those of the Saurian reptiles of the Bristol conglomerate. In their breadth, as compared with their length and thickness, they are intermediate between the *Thecodontosaurus* and the *Palæosaurus platyodon*. They are also larger and more recurved, and thus more nearly approach the form characteristic of the teeth of the *Megalosaurus*. From these teeth, however, they differ in their greater degree of compression and in a slight contraction of the base of the crown."

Figures of these teeth, of the natural size, are given in Plate 62 A, figs. 4 a & b, of the work cited.

[1] On this question I refer the reader to a forthcoming paper by my colleague, Mr. Etheridge.

I am at a loss to discover the smallest resemblance between these teeth and either those of *Thecodontosaurus* of Riley and Stutchbury or the so-called "*Palæosaurus*" *platyodon* tooth, which is represented in the same plate, fig. 7; nor can I divine in what sense the *Cladyodon* teeth can be said to be intermediate between the two. If they were affirmed to be intermediate between *Thecodontosaurus* and *Palæosaurus cylindrodon*, the statement would be intelligible, though I do not think it would be altogether accurate.

I have been favoured by Mr. T. G. B. Lloyd, F.G.S., with the opportunity of examining three Saurian teeth from the quarries which yielded *Cladyodon*. Two of these teeth (Pl. III. [Plate 29], fig. 4) are so similar to those of *Palæosaurus cylindrodon* in form, and even in colour, that I conceive them to belong to the same genus, and perhaps to the same species, although they are twice as large as the teeth from Bristol. They show most distinctly the abrupt cessation of the anterior serrated ridge about halfway down the crown, which beneath this point is rounded and curved as in *Megalosaurus*. I see no reason to doubt that these are Dinosaurian teeth. Of the other tooth only the crown, which is 1·8 inch long, is preserved (Pl. III. [Plate 29], fig. 11). This tooth must have had, as nearly as may be, the same dimensions as the hindmost tooth in the upper jaw of the *Megalosaurus* figured in the 'Quarterly Journal' of this Society (vol. xxv. pl. 12), and if placed over that tooth it corresponds with it in contour with remarkable closeness. On the whole, however, the crown of the Megalosaurian tooth is thicker near the fang than the present tooth. But what distinguishes the latter at once from all the Megalosaurian teeth of which I have been able to obtain a sufficiently clear view, is the fact that the serrated anterior ridge extends along the whole length of the crown, instead of stopping short halfway from the apex, as it does in *Megalosaurus*. In this respect the tooth from the Trias resembles those of *Teratosaurus*; and it may possibly belong to that genus.

Thus it appears that there are two kinds of Dinosaurian teeth in the Warwickshire Trias—one kind allied to *Megalosaurus*, the other to *Thecodontosaurus*.

Thanks to Mr. Kirshaw, who has so skilfully worked out many of the fossils of the Warwickshire Trias, I am able to add new evidence which tends in the same direction. This consists of three consecutive vertebræ (Pl. III. [Plate 29], fig. 9), which have been ankylosed together, though they are now separated by the breaking away of the greater part of the hinder portion of the second vertebra. The centra of these vertebræ are much constricted in the middle, while their

articular surfaces are flat or slightly excavated (Pl. III. [Plate 29], fig. 10). The bones have been so much distorted and crushed that it is hard to say what the contour of these surfaces may have been; but they were either circular or oval, the long axis of the ellipse being vertical. The spinous processes are broken away. The faces of the præzygapophyses look inwards as well as upwards, so as to embrace the postzygapophyses of the antecedent vertebra laterally. The postzygapophyses of the first vertebra are completely ankylosed with those of the second; and those of the second seem to have been similarly united with those of the third. The centrum of the first vertebra, on the other hand, is not absolutely fused with that of the second, the separation being everywhere traceable; and the union between the centra of the second and third vertebræ seems to have been still more lax. Each neural arch is connected only with its own centrum, and the intervertebral foramen lies over the posterior moiety of each centrum.

A strong, prismatic sacral rib with a triangular section, only the proximal end of which remains, springs from the junction of the centrum with the neural arch on each side, in the first vertebra, and appears to have been directed perpendicularly outwards. The second vertebra seems to have possessed a similar rib, which, however, springs rather further back from the anterior edge of the arch. The third vertebra also possesses a strong rib, the root of which occupies the middle of the arch. The contour of the broken end of the rib is more nearly four-sided. The anterior and posterior faces are concave from above downwards, and are directed obliquely, the anterior upwards, and the posterior downwards. The centrum of the anterior vertebra is 1·6 inch long, that of the third 1·75 inch; but the difference may be the result of the crushing of the vertebræ, which are a good deal distorted. The height of the centrum seems to have been about 1·3 inch, the width about 1·1 inch.

Mr. Kirshaw has sent me two centra of vertebræ, which may very well have belonged to the same animal as the sacrum. One of these is almost undistorted, and belongs to the dorsal region. It is 1 6 inch long; and the better preserved articular surface is 1·55 inch high, while its greatest width is rather less than 1 inch. The surface is very slightly concave, and is perpendicular to the axis of the centrum. The centrum is much constricted, so as to be not more than 0·6 inch wide in the middle: and, as in the other vertebræ, the floor of the neural canal sinks rapidly from each end towards the middle of the centrum. Some of the vertebræ from the Bristol conglomerate bear an extraordinarily close resemblance to these.

The fragmentary vertebra described and figured by Professor Owen as belonging to *Labyrinthodon pachygnathus* has the same general characters as those now described. The vertebra ascribed to *Labyrinthodon leptognathus*, on the other hand, appears to have belonged to some other reptile.

The remarkable ilium ascribed to *Labyrinthodon pachygnathus* (*l. c.* pl. 45, figs. 16, 17), is also a reptilian bone, intermediate in its characters between the ilium of a Teleosaurian and that of a Lizard. It is very similar to an ilium from the Keuper described and figured by Von Meyer ('Palæontographica,' Bd. vii. pl. 41), and ascribed by him to *Belodon*. I propose to discuss the nature and signification of this remarkable bone in another communication.

I have no direct evidence of the presence of *Dinosauria* in the Elgin sandstones; but ample proof is in my possession that the cast of a mandible, which I have described ('Quarterly Journal of the Geological Society,' 1858, vol. xv. p. 454) as probably appertaining to *Stagonolepis*, did not belong to that reptile, the teeth of which possess short and comparatively obtuse crowns. I think it more than probable that this mandible, with its great recurved and pointed teeth, which had large pulp-cavities and were implanted in distinct alveoli, may have belonged to a Dinosaurian reptile.

I know of no further evidence of the existence of *Dinosauria* in rocks of Triassic age in Western Europe than that which I have now brought forward; but it is sufficient to demonstrate the existence of, at fewest, two genera in the German Trias, and of three in that of Britain.

3. DINOSAURIA *from the Trias of the Ural Mountains and India.*

In the extreme east of Europe, namely in the Ural Mountains there is a series of rocks which have been supposed to be Permian, but which there now appears to be every reason to consider to be of Triassic age. Remains of reptiles associated with those of Labyrinthodonts from these rocks have been described and figured by D'Eichwald ('Lethæa Rossica') and by Von Meyer ('Palæontographica,' Bd. xv.). Now the teeth and jaws of the *Deuterosaurus* of D'Eichwald, no less than the vertebræ which are referred to the same genus by this author, have a strongly Dinosaurian aspect; and though the evidence is incomplete, I am greatly inclined to think that *Deuterosaurus* is a Dinosaurian. But the specially interesting feature of the Ural Triassic fauna is the association with the Labyrinthodonts and possible *Dinosauria*, of the *Rhopalodon*, so singular for its great

canine tusks, in front of and behind which were comparatively small "incisors" and "molars;" for no one who compares *Rhopalodon* with the *Galesaurus* of Prof. Owen, from the Dicynodont-yielding sandstones of South Africa, can fail to see that the two forms are closely allied.

On the other hand, Von Meyer describes humeri and portions of crania from the same deposits, the nearest resemblance to which he finds in the corresponding parts of the skeleton of *Dicynodon* itself. Thus there is a clear affinity between the Triassic fauna of the Ural and that of South Africa. But in the Ural we have reached a point halfway between the West of England and Central India. I have already ("Palæontologica Indica," in 'Memoirs of the Geological Survey of India,' 1865) shown reason for the belief that the Central Indian and the African faunæ of the "Poikilitic" period were closely allied; and I have described a small Thecodont Saurian (*Ankistrodon*) from the Indian beds. Thanks to Professor Oldham (the Director of the Indian Survey), I am now enabled to go a step further; for among the remains which last reached me from him there are portions of a Crocodilian closely allied to *Belodon*; and thus the Indian fauna, together with that of the Ural, binds the Triassic fauna of Western Europe with that of Africa.[1]

4. DINOSAURIA *from the Trias of North America.*

The Trias of North America has yielded the remains of two forms of reptiles, *Clepsysaurus* and *Bathygnathus*.[2] The teeth, jaw-fragments, and vertebræ of these reptiles have characters which are quite in accordance with those of the *Dinosauria*, to which group they have lately been referred by Cope and Leidy, and I entertain no doubt that they are *Dinosauria*; but, unfortunately, none of the remains which have been discovered belong to what may be called *diagnostic* bones, such as the ilium, the femur, or the tibia.

5. *The Arctogæal province constituted in Triassic Times.*

Assuming, provisionally, that these reptiles are *Dinosauria*, the distribution of that group and of the other *Reptilia* and *Amphibia* of the Trias may bə tabulated in the form on page 504.

[1] A fragment of a jaw from Malédi reminds me forcibly of *Rhopalodon*.

[2] See the memoirs by Lea and Leidy in the second volume of the second series of the Journal of the Academy of Natural Sciences.'

thus formulated by d'Archiac, "How are the fossils of a formation distributed in the different stages of that formation? And what modifications or changes do the species undergo, on the one hand, in time, as we pass from one stage to another, and, on the other, in space, as we examine the formation at different points of its geographical extent?"

In order to solve the problem thus stated, M. d'Archiac observes that it is necessary to select a formation which can be studied upon its circumference, and at a great number of intermediate points, which has not undergone any serious dislocation, and all the stages of which present definite marks by which they can be compared.

The Cretaceous formation, stretching from Burgundy to Dorsetshire, appearing to fulfil these conditions, was therefore subjected to a minute and exhaustive study, and it yielded the following replies to the questions proposed:—The more the different stages of a formation are developed, the more distinct are the organisms which they contain, or, in other words, the smaller is the number of species common to any two of them. Further, as the number of the members of the same formation diminishes, on the one hand, the species of the different stages tend to become mixed together; and on the other, new species, and even new genera, appear in inverse proportion to the number of the stages which persist. Thus the fossils at the margins of the Middle Cretaceous formation differ from those of its centre, and, moreover, they differ geographically. The cretaceous organisms inhabit three zones, a northern, a middle, and a southern, and these have a general direction from N.W. to S.E., which probably corresponds with that of the isothermal lines of the period.

The sixth volume of the 'Transactions' of our Society is adorned by a very elaborate memoir "On the Fossils of the older Deposits in the Rhenish Provinces," in which, in conjunction with our distinguished foreign member M. de Verneuil, M. d'Archiac subjects a great section of palæozoic life to a similar investigation, and conclusions of no less importance are there stated:—"If the development of palæozoic organisms be considered relatively to the thickness of the beds, or the duration of the epoch, we shall see, 1st, *that the total number of species always increases from below upwards;* 2nd, *that the progression is very different in each order and in each family, and that this progression is even frequently inverse, either in the different orders of the same class, or in the various genera of the same order.* If, on the other hand, the development of the palæozoic creation be considered relatively to its horizontal extent, or geographically in relation *to space*, it will be seen, 1st, *that the*

early volume, as far as 1845, in the later volumes to a more recent date. The last volume deals with the history of Triassic geology from 1834 to 1859.

In 1857 M. d'Archiac was selected a member of the Academy of Sciences, in the place of M. Constant Prévost; and, on the death of Alcide d'Orbigny, in 1861, he was nominated to fill the chair of palæontology in the Muséum d'Histoire Naturelle in Paris.

The substance of four of the courses of lectures which M. d'Archiac delivered in his new capacity has been published in three volumes, under the title of 'Cours de Paléontologie Stratigraphique.' The first volume contains a précis of the history of palæontology; the second is devoted to a general view of biology, as an introduction to palæontology; while the third gives an account of the fauna of the Quaternary epoch. At this point the series of the 'Cours de Paléontologie' ceases; but, in 1866, a complete treatise, embodying M. d'Archiac's views on the totality of geological phenomena, entitled 'Géologie et Paléontologie,' appeared.

The last work from M. d'Archiac's pen is the great Report on the Palæontology of France, which was published in 1868.

All who have known M. d'Archiac personally, speak in the warmest terms of the uprightness of his character, and of his keen sense of honour and independence. And it is lamentable to know that the pressure of petty cares so destroyed the balance of his sensitive and finely-strung mind, that a few more years of patient endurance of such troubles appeared as little possible to him as any application for help to the many friends who were not only able, but would have been proud to serve him. The Vicomte d'Archiac was in his sixty-seventh year at the time of his death.

JOSEPH BEETE JUKES, Fellow of the Royal Society, was born in Birmingham on the 18th of October, 1811, and was educated partly at the Merchant Taylors' School in Wolverhampton, and partly at King Edward's School in Birmingham. At the latter school he gained an exhibition, which took him to Cambridge, where he entered St. John's College in 1830, and took his B.A. degree in 1836, proceeding to his M.A. in 1841.

The genial enthusiasm and large knowledge of the Woodwardian Professor of Geology, then in his vigorous prime, worked upon Mr. Jukes, as they seem to have affected all men who came within the range of their influence, and determined him to make geological investigation the vocation of his life. Immediately after leaving

district about Bala and Conway during the summers of several years, while the winters were employed in surveying the Coal-measures of his native county.

The results of the latter work appeared among the publications of the Survey in 1853, as a 'Memoir on the Geology of the South Staffordshire Coal-fields,' which is of very great importance, alike in its scientific and in its practical bearings. So strongly was its value in the latter direction felt by the public, that the first edition of the memoir was exhausted in a few years, and of a second revised and enlarged edition, which was published in 1858, not a copy now remains.

In 1850 Mr. Jukes was appointed Local Director of the Irish branch of the Survey, in room of Prof. Oldham, who had undertaken the direction of the Geological Survey of India. In this capacity Mr. Jukes laboured for nineteen years, with unremitting energy, and the most conscientious desire to do his duty, in a position which was full of difficulties and involved much wear and tear of both mind and body. During this period, he edited and largely contributed to no fewer than forty-two memoirs explanatory of the geological maps of the southern, eastern, and western parts of Ireland, executed by the Survey.

In addition to these labours Mr. Jukes for many years discharged the functions of a Professor of Geology, first in connexion with the Royal Dublin Society and Museum of Irish Industry, and afterwards in the Royal College of Science in Dublin. He wrote a very good elementary manual of geology, and some school-books upon geology and physical geography; and he read a large number of papers and notices before this Society and the Geological Society of Dublin, of which last body he was President during the years 1853 and 1854. Several of these papers, such as that "On the mode of formation of some of the river-valleys of the South of Ireland," show how completely Mr. Jukes shared with his colleagues, Prof. Ramsay and others, that tendency to return to Huttonian methods of accounting for the form of terrestrial surfaces which is so marked a feature of a rising and active school of geologists.

The Fellows of this Society have, doubtless, a clear recollection of the discussions to which two of Mr. Jukes's papers, that "On the mode of formation of river-valleys of the South of Ireland," to which I have just referred, and that "Upon the Carboniferous slates and Devonian rocks and the Old Red Sandstone of the South of Ireland," gave rise. They will have a vivid remembrance of the heartiness and vigour with which our colleague threw himself into the defence of

bone; and it includes four essays which offer a good example of the extent and variety of Von Meyer's knowledge, even at that time. The first is upon an Orthoceratite, the second upon *Mastodon arvernensis*, the third on *Aptychus*, the fourth on two new fossil reptiles, *Rhacheosaurus* and *Pleurosaurus*. For thirty years Von Meyer poured fourth a continuous torrent of excellent and richly illustrated memoirs, sometimes upon *Mollusca*, sometimes on *Crustacea*, sometimes upon Fishes, but most commonly upon Reptiles and *Mammalia*.

The most complete monograph extant on the *Amphibia* of the Carboniferous epoch is by Von Meyer; the only monograph upon the Permian *Reptilia* is also from his pen. The great work upon the Fauna of the Muschelkalk, which was published in 1847–1852, is a wonderful monument of patient and skilful labour, and when it appeared, effected a revolution in the minds of geologists as to the character of the Triassic fauna, which instead of being poverty-stricken, as some supposed, revealed about eighty species of Labyrinthodonts and Reptiles in Germany alone. This fine monograph was supplemented by several excellent memoirs on the Triassic Fauna in the 'Palæontographica.' No less valuable is the work upon the Fauna of the Lithographic slates, which affords a complete conspectus of the Reptiles of that rich deposit.

In the preface to the memoir on the fossils of Georgensgmünd, to which I have already referred, Von Meyer makes some excellent remarks on the value of drawing as a help to the palæontologist, and on the frequent imperfections of drawings of fossils, and especially of osteological subjects, which are not made by persons conversant with anatomy. "I knew all this well enough," says he, "but I had no practice with the pencil, nor any experience in managing light and shade." This was a difficulty which would have appalled most men, but not Von Meyer, who set to work to teach himself drawing; with what admirable success all who are familiar with his works know. For it was Von Meyer's practice to draw all the illustrations of his numerous memoirs on the stone; and, at a rough estimate, some hundreds of quarto and folio plates must have proceeded from his swift and accurate pencil. There are seventy folio plates in the 'Saurier des Muschelkalkes' alone.

Though he must have devoted an immense amount of time and labour to the mere details of palæontological work, it would be a great mistake to count Von Meyer among the mere men of detail. On the contrary, his 'Palæologica,' published in 1832, is full of instructive and original thought, especially the second essay of the

into Wales, and did his first field-geology under Sedgwick's teaching, whom he always referred to as "the Master."

In 1846 he married Sally, second daughter of Mr. J. De Carle Sowerby, with whom he had learnt that art of which, in the illustrations to so many scientific works, he has left testimony showing not only the ability of the master but the aptitude of the pupil.

In the same year, at the age of 26, he entered upon the Geological Survey, and for eight years served as chief assistant to the palæontologist, Prof. Edward Forbes. Writing to his friend Dr. Grindrod, of Malvern, Salter says,[1] "From 1846 to the time of Forbes's removal to Edinburgh in 1854, I shared with him the arrangement, description, and cataloguing of the public fossil collections of the Survey, took part in the field-work, and in all other duties shared the work with him and had his full approval."

On the retirement of Edward Forbes it was found expedient to separate the Lectureship on Natural History from the Office of Palæontologist. Prof. Huxley was accordingly appointed to the former post, that of Naturalist to the Geological Survey, while Mr. Salter was installed in the latter office.

In consequence of the increasing extent of the labours of the Geological Surveyors, the examination of the Irish fossils was, in 1856, handed over to Mr. W. Hellier Baily, and in the following year Mr. Robert Etheridge, having been appointed Assistant Naturalist to the Geological Survey, took charge of the fossils of the Secondary and Tertiary formations of Britain, thus leaving Mr. Salter free to devote his whole energies to his favourite work—the fossils of the palæozoic formations.

During his period of office Mr. Salter prepared three Decades, with 10 plates each (8vo size), on the Trilobites in the collection at Jermyn Street, and, in conjunction with Prof. Huxley, a Monograph on the genus *Pterygotus*, illustrated with sixteen folio plates. He also completed a Decade on the *Echini*, commenced by Prof. Forbes, and supplied a part of the palæontology to Prof. Phillips's 'Memoir on Malvern.'

The palæontological portion of Prof. Ramsay's 'Memoirs on North Wales' was also written by Mr. Salter.

The officer holding the position of Palæontologist to the Geological Survey of Great Britain has a large amount of routine work in

[1] The letter we refer to is dated "Leicester House, Malvern, Nov. 14, 1868," and is addressed to Dr. Grindrod and W. Mathews, Esq., M.A., F.G.S., and appears to have been intended for publication, with a view to soliciting a pension from Government, which owing to his retiring at the end of 17 years' service (in 1863), he was not entitled to claim.

tasks which he undertook; it remains uncompleted, as does his Monograph on the Trilobites.

It is difficult to say what combination of official conditions could have been found better suited to him than those in which he was placed. He often pictured the happiness of a post in the British Museum; but it is doubtful, had he realized his hope, whether his health would have improved. Those who knew him well will remember how cheerful and light-hearted he was at times; he was, in many ways, remarkably like a child, fond of boyish athletic sports, a lover of Nature, fond of wild flowers and domestic pet animals, which he encouraged his children to keep. Anon he would be fretful and irritable, often without any reasonable cause, proving that the chronic ill-health of which he complained was certainly mental.

His staunch friends, Murchison and Sedgwick, helped him right manfully throughout, and he had many friends in the West of England and of Scotland, who gladly welcomed him to their homes and cordially sympathized with him. But though he spoke cheerfully and hopefully after resigning his post at Jermyn Street, there is no doubt that he regretted the step he had taken.

No one, however, who will fairly weigh the amount of valuable work done by Mr. Salter, and the large contributions he has made to our knowledge of the palæozoic rocks and the early life-forms which they contain, will deny that a man of such ability deserved some recognition in the way of pension from Government; and it is sincerely to be hoped that Mrs. Salter with her seven children, may at least be granted some small share of the Royal bounty, as some acknowledgment of the services rendered to science by her husband.

Mr. Salter is buried in Highgate Cemetery, the resting-place of several of his fellow-workers in science.

RICHARD NATHANIEL RUBIDGE, M.B. Lond., who was well known as an enthusiastic labourer in the geology of South Africa, died suddenly, at Port Elizabeth, on the 8th of August, 1869. Beginning his medical studies under Dr. John Atherstone, of Port Elizabeth, his habit of accurate observation was acquired and fostered in company with his fellow pupil and friend, Dr. W. G. Atherstone, of that town, also known as an ardent and successful geological explorer of South Africa, some time in company with the late Mr. A. G. Bain, who first worked out and mapped the geology of that region.

schistose rocks of Cape Town, of the Bokkeveld, George, and southern Uitenhage (whence he got Devonian fossils) to be all of the same date. Certainly a great advance was made in proving the continuation of the Bokkeveld schists into the last-named district; but whether the schists and slates of the Cape come into the same category still requires careful inquiry.

Examining the neighbourhood of the Zuerberg, in occasional journeys, Dr. Rubidge endeavoured to throw light on the stratification and structure of that country, showing that the Lower Ecca beds are probably of Devonian age. For the illustration of his views on this matter he sent several series of rocks and fossils to the Geological Society of London, and he communicated papers on the subject to that Society, to the 'Geologist,' to the British Association, and to the periodicals of Port Elizabeth. In 1864 he visited England, and travelled to the north with the special view of studying schistose and quartzose rocks like those of the Zuerberg. He brought with him many new fossils, of Secondary age, from the Uitenhage district, and went to considerable expense in getting them properly examined and determined, intending ultimately to produce a general work on the geology of the colony. The fossils constituted a valuable addition to the South African collection in the Geological Society's Museum, and were fully described, with illustrations, in the Society's Journal, by Mr. R. Tate, in 1867.

So long ago as 1854, Dr. Rubidge wrote to his geological correspondents in London on the subject of aërial denudation, which had not then received so much attention from European geologists as it deserved. In 1866 he reproduced the chief points of his letters in the 'Geological Magazine,' No. 20, bringing forward evidence of the enormously extensive and long-continued denudation of the interior of South Africa, subsequent to its leaving the sea and since the lacustrine deposits of the Karoo formations were drained dry.

As an observer and as a generalizer, then, Dr. Rubidge was energetic and bold, adding much to the store of geological facts and thought, though working hard throughout in his professional practice, and often suffering from ill-health. Heart disease has taken him off suddenly (at the age of about forty-eight) from amongst his friends, before his well-loved work was finished as he wished; but he had always given his best attention to the advancement of science in general, and of geology in particular, among the community around him; and having always identified himself with the Literary and Scientific Institutions of Port Elizabeth, and

he used in combination with one who in his lifetime was honoured as a ripe scholar and a man of cultivated taste, Mr. John Scandret Harford, of Blaize Castle. Mr. Sanders gave some £200 as a first subscription towards the building-fund, and beyond that we have reasons to know that he supplied a deficiency which would have resulted from the breach of his promise by one who had undertaken to subscribe £100. Somewhat early in the history of the Institution he was elected to a distinguished honorary position in connexion with it, and for many years, and till the day of his death, he was one of its vice-presidents. His attachment to the undertaking, and to the important educational objects sought by it, never ceased. He was always a willing subscriber to its funds; and about nine years ago, when it became questionable whether the Museum could be kept up, he gave the princely sum of £1000 towards an Endowment Fund, to be applied to its future maintenance. To the force of his public-spirited example on that occasion the citizens of Bristol are mainly indebted for the preservation and rearrangement of a host of treasures which, thanks also to the untiring zeal of his nephew, Mr. William Sanders, F.G.S., Honorary Curator, are known to and prized by men of science throughout the empire. At the time of his death Mr. Sanders was in the 94th year of his age; but, with the exception of partial deafness, he retained his faculties almost to the last, and within a couple of months of his death he could read small type without the aid of spectacles.

It is now eight years since, in the absence of the late Mr. Leonard Horner, who then presided over us, it fell to my lot, as one of the Secretaries of this Society, to draw up the customary Annual Address. I availed myself of the opportunity to endeavour to "take stock" of that portion of the science of biology which is commonly called "palæontology," as it then existed; and, discussing one after another the doctrines held by palæontologists, I put before you the results of my attempts to sift the well-established from the hypothetical or the doubtful. Permit me briefly to recall to your minds what those results were:—

1. The living population of all parts of the earth's surface which have yet been examined has undergone a succession of changes which, upon the whole, have been of a slow and gradual character.

2. When the fossil remains which are the evidences of these successive changes, as they have occurred in any two more or less distant parts of the surface of the earth, are compared, they exhibit

recognized geological doctrine that the species of one formation all died out and were replaced by a brand-new set in the next formation. On the contrary, it is generally, if not universally, agreed that the succession of life has been the result of a slow and gradual replacement of species by species; and that all appearances of abruptness of change are due to breaks in the series of deposits, or other changes in physical conditions. The continuity of living forms has been unbroken from the earliest times to the present day.

2, 3. The use of the word "homotaxis" instead of "synchronism" has not, so far as I know, found much favour in the eyes of geologists. I hope, therefore, that it is a love for scientific caution, and not mere personal affection for a bantling of my own, which leads me still to think that the change of phrase is of importance, and that the sooner it is made, the sooner shall we get rid of a number of pitfalls which beset the reasoner upon the facts and theories of geology.

One of the latest pieces of foreign intelligence which has reached us is the information that the Austrian geologists have, at last, succumbed to the weighty evidence which M. Barrande has accumulated, and have admitted the doctrine of colonies. But the admission of the doctrine of colonies implies the further admission that even identity of organic remains is no proof of the synchronism of the deposits which contain them.

4. The discussions touching the *Eozoon*, which commenced in 1864, have abundantly justified the fourth proposition. In 1862, the oldest record of life was in the Cambrian rocks; but if the *Eozoon* be, as Principal Dawson and Dr. Carpenter have shown so much reason for believing, the remains of a living being, the discovery of its true nature carried life back to a period which, as Sir William Logan has observed, is as remote from that during which the Cambrian rocks were deposited, as the Cambrian epoch itself is from the tertiaries. In other words, the ascertained duration of life upon the globe was nearly doubled at a stroke.

5. The significance of persistent types, and of the small amount of change which has taken place even in those forms which can be shown to have been modified, becomes greater and greater in my eyes, the longer I occupy myself with the biology of the past.

Consider how long a time has elapsed since the Miocene epoch. Yet, at that time, there is reason to believe that every inportant group in every order of the *Mammalia* was represented. Even the comparatively scanty Eocene fauna yields examples of the orders *Chiroptera*, *Insectivora*, *Rodentia*, and *Perissodactyla*; of *Artiodactyla*

Many years ago[1] I ventured to speak of the Atlantic mud as "modern chalk," and I know of no fact inconsistent with the view which Professor Wyville Thomson has advocated, that the modern chalk is not only the lineal descendant of the ancient chalk, but that it remains, so to speak, in the possession of the ancestral estate; and that from the Cretaceous period (if not much earlier) to the present day, the deep sea has covered a large part of what is now the area of the Atlantic. But if *Globigerina*, and *Terebratula caput-serpentis* and *Beryx*, not to mention other forms of animals and of plants, thus bridge over the interval between the present and the Mesozoic periods, is it possible that the majority of other living things underwent a "sea-change into something new and strange" all at once?

6. Thus far I have endeavoured to expand and to enforce by fresh arguments, but not to modify in any important respect, the ideas submitted to you on a former occasion. But when I come to the propositions touching progressive modification, it appears to me with the help of the new light which has broken from various quarters, that there is much ground for softening the somewhat Brutus-like severity with which, in 1862, I dealt with a doctrine, for the truth of which I should have been glad enough to be able to find a good foundation. So far, indeed, as the *Invertebrata* and the lower *Vertebrata* are concerned, the facts and the conclusions which are to be drawn from them appear to me to remain what they were. For anything that, as yet, appears to the contrary, the earliest known Marsupials may have been as highly organized as their living congeners; the Permian lizards show no signs of inferiority to those of the present day; the Labyrinthodonts cannot be placed below the living Salamander and Triton; the Devonian Ganoids are closely related to *Polypterus* and to *Lepidosiren*.

But when we turn to the higher *Vertebrata*, the results of recent investigations, however we may sift and criticize them, seem to me to leave a clear balance in favour of the doctrine of the evolution of living forms one from another. In discussing this question, however, it is very necessary to discriminate carefully between the different kinds of evidence from fossil remains which are brought forward in favour of evolution.

Every fossil which takes an intermediate place between forms of life already known, may be said, so far as it is intermediate, to be evidence in favour of evolution, inasmuch as it shows a possible road by which evolution may have taken place. But the mere discovery of such a form does not, in itself, prove that evolution took

[1] 'Saturday Review,' 858, "Chalk Ancient and Modern."

Mesopithecus as an intercalary form between the *Semnopitheci* and the *Macaci*; and among the *Carnivora*, *Hyænictis* and *Ictitherium* as intercalary, or, perhaps, linear types between the *Viverridæ* and the *Hyænidæ*.

Hardly any order of the higher *Mammalia* stands so apparently separate and isolated from the rest as that of the *Cetacea*; though a careful consideration of the structure of the pinnipede *Carnivora*, or Seals, shows, in them, many an approximation towards the still more completely marine mammals. The extinct *Zeuglodon*, however, presents us with an intercalary form between the type of the Seals and that of the Whales. The skull of this great Eocene sea-monster, in fact, shows—by the narrow and prolonged interorbital region; the extensive union of the parietal bones in a sagittal suture; the well-developed nasal bones; the distinct and large incisors implanted in premaxillary bones, which take a full share in bounding the fore part of the gape; the two-fanged molar teeth with triangular and serrated crowns, not exceeding five on each side in each jaw; and the existence of a deciduous dentition—its close relation with the Seals. While, on the other hand, the produced rostral form of the snout, the long symphysis, and the low coronary process of the mandible are approximations to the cetacean form of those parts.

The scapula resembles that of the cetacean *Hyperoodon*, but the supraspinous fossa is larger and more seal-like; as is the humerus, which differs from that of the *Cetacea* in presenting true articular surfaces for the free jointing of the bones of the forearm. In the apparently complete absence of hinder limbs, and in the characters of the vertebral column, the *Zeuglodon* lies on the cetacean side of the boundary line; so that, upon the whole, the Zeuglodonts, transitional as they are, are conveniently retained in the cetacean order. And the publication, in 1864, of M. Van Beneden's memoir on the Miocene and Pliocene *Squalodon*, furnished much better means than anatomists previously possessed of fitting in another link of the chain which connects the existing *Cetacea* with *Zeuglodon*. The teeth are much more numerous, although the molars exhibit the zeuglodont double fang; the nasal bones are very short, and the upper surface of the rostrum presents the groove, filled up during life by the prolongation of the ethmoidal cartilage, which is so characteristic of the majority of the *Cetacea*.

It appears to me that, just as among the existing *Carnivora*, the walruses and the eared seals are intercalary forms between the fissipede Carnivora and the ordinary seals, so the Zeuglodons are intercalary between the *Carnivora*, as a whole, and the *Cetacea*.

Whether the Zeuglodonts are also linear types in their relation to these two groups cannot be ascertained, until we have more definite knowledge than we possess at present, respecting the relations in time of the *Carnivora* and *Cetacea*.

Thus far we have been concerned with the intercalary types which occupy the intervals between Families or Orders of the same class; but the investigations which have been carried on by Prof. Gegenbaur, Prof. Cope, and myself into the structure and relations of the extinct reptilian forms of the *Ornithoscelida* (or *Dinosauria* and *Compsognatha*) have brought to light the existence of intercalary forms between what have hitherto been always regarded as very distinct classes of the vertebrate subkingdom, namely *Reptilia* and *Aves*. Whatever inferences may, or may not, be drawn from the fact, it is now an established truth that in many of these *Ornithoscelida* the hind limbs and the pelvis are much more similar to those of Birds than they are to those of Reptiles, and that these Bird-reptiles or Reptile-birds were more or less completely bipedal.

When I addressed you in 1862, I should have been bold indeed had I suggested that palæontology would before long show us the possibility of a direct transition from the type of the lizard to that of the ostrich. At the present moment we have, in the *Ornithoscelida*, the intercalary type, which proves that transition to be something more than a possibility; but it is very doubtful whether any of the genera of *Ornithoscelida* with which we are at present acquainted are the actual linear types by which the transition from the lizard to the bird was effected. These, very probably, are still hidden from us in the older formations.

Let us now endeavour to find some cases of true linear types, or forms which are intermediate between others because they stand in a direct genetic relation to them. It is no easy matter to find clear and unmistakable evidence of filiation among fossil animals; for, in order that such evidence should be quite satisfactory, it is necessary that we should be acquainted with all the most important features of the organization of the animals which are supposed to be thus related, and not merely with the fragments upon which the genera and species of the palæontologist are so often based. M. Gaudry has arranged the species of *Hyænidæ*, *Proboscidea*, *Rhinocerotidæ*, and *Equidæ* in their order of filiation from their earliest appearance in the Miocene epoch to the present time, and Professor Rütimeyer has drawn up similar schemes for the Oxen and other *Ungulata*—with what, I am disposed to think, is a fair and probable approximation to the order of nature. But, as no one is better aware than these two

learned, acute, and philosophical biologists, all such arrangements must be regarded as provisional, except in those cases in which, by a fortunate accident, large series of remains are obtainable from a thick and wide-spread series of deposits. It is easy to accumulate probabilities—hard to make out some particular case in such a way that it will stand rigorous criticism.

After much search, however, I think that such a case is to be made out in favour of the pedigree of the Horses.

The genus *Equus* is represented as far back as the latter part of the Miocene epoch; but in deposits belonging to the middle of that epoch its place is taken by two other genera, *Hipparion* and *Anchitherium*;[1] and in the lowest Miocene and upper Eocene only the last genus occurs. A species of *Anchitherium* was referred by Cuvier to the *Palæotheria*, under the name of *P. aurelianense*. The grinding-teeth are in fact very similar in shape and in pattern, and in the absence of any thick layer of cement, to those of some species of *Palæotherium*, especially Cuvier's *Palæotherium minus*, which has been formed into a separate genus, *Plagiolophus*, by Pomel. But in the fact that there are only six full-sized grinders in the lower jaw, the first premolar being very small, that the anterior grinders are as large as or rather larger than the posterior ones, that the second premolar has an anterior prolongation, and that the posterior molar of the lower jaw has, as Cuvier pointed out, a posterior lobe of much smaller size and different form, the dentition of *Anchitherium* departs from the type of the *Palæotherium*, and approaches that of the Horse.

Again, the skeleton of *Anchitherium* is extremely equine. M. Christol goes so far as to say that the description of the bones of the horse or the ass, current in veterinary works, would fit those of *Anchitherium*. And, in a general way, this may be true enough; but there are some most important differences, which, indeed, are justly indicated by the same careful observer. Thus the ulna is complete throughout, and its shaft is not a mere rudiment, fused into one bone with the radius. There are three toes, one large in the middle and one small on each side. The femur is quite like that of a horse, and has the characteristic fossa above the external condyle.

[1] Hermann von Meyer gave the name of *Anchitherium* to *A. Ezquerræ*; and in his paper on the subject he takes great pains to distinguish the latter as the type of a new genus, from Cuvier's *Palæotherium d'Orleans*. But it is precisely the *Palæotherium d'Orleans* which is the type of Christol's genus *Hipparitherium*; and thus, though *Hipparitherium* is of later date than *Anchitherium*, it seemed to me to have a sort of equitable right to recognition when this address was written. On the whole, however, it seems most convenient to adopt *Anchitherium*.

The process by which the *Anchitherium* has been converted into *Equus* is one of specialization, or of more and more complete deviation from what might be called the average form of an ungulate mammal. In the Horses, the reduction of some parts of the limbs, together with the special modification of those which are left, is carried to a greater extent than in any other hoofed mammals. The reduction is less and the specialization is less in the *Hipparion*, and still less in the *Anchitherium*; but yet, as compared with other mammals, the reduction and specialization of parts in the *Anchitherium* remains great.

Is it not probable then, that, just as in the Miocene epoch, we find an ancestral equine form less modified than *Equus*, so, if we go back to the Eocene epoch, we shall find some quadruped related to the *Anchitherium*, as *Hipparion* is related to *Equus*, and consequently departing less from the average form?

I think that this desideratum is very nearly, if not quite, su pplied by *Plagiolophus*, remains of which occur abundantly in some parts of the Upper and Middle Eocene formations. The patterns of the grinding-teeth of *Plagiolophus* are similar to those of *Anchitherium*, and their crowns are as thinly covered with cement; but the grinders diminish in size forwards, and the last lower molar has a large hind lobe, convex outwards, and concave inwards, as in *Palæotherium*. The ulna is complete and much larger than in any of the *Equidæ*, while it is more slender than in most of the true *Palæotheria*; it is fixedly united but not anchylosed with the radius. There are three toes in the fore limb, the outer ones being slender, but less attenuated than in the *Equidæ*. The femur is more like that of the *Palæotheria* than that of the horse, and has only a small depression above its outer condyle in the place of the great fossa which is so obvious in the *Equidæ*. The fibula is distinct, but very slender, and its distal end is anchylosed with the tibia. There are three toes on the hind foot having similar proportions to those on the fore foot. The principal metacarpal and metatarsal bones are flatter than they are in any of the *Equidæ*; and the metacarpal bones are longer than the metatarsals, as in the *Palæotheria*.

In its general form, *Plagiolophus* resembles a very small and slender horse;[1] and is totally unlike the reluctant, pig-like creature depicted in Cuvier's restoration of his *Palæotherium minus* in the 'Ossemens Fossiles.'

[1] Such, at least, is the conclusion suggested by the proportions of the skeleton figured by Cuvier and De Blainville; but perhaps something between a Horse and an Agouti would be nearest the mark.

Dichobune occurs in the Middle Eocene and is, in fact, the oldest known artiodactyle mammal. Where, then, must we look for its five-toed ancestor?

If we follow down other lines of recent and tertiary *Ungulata*, the same question presents itself. The Pigs are traceable back through the Miocene epoch to the Upper Eocene, where they appear in the two well-marked forms of *Hyopotamus* and *Chœropotamus*: but *Hyopotamus* appears to have had only two toes.

Again, all the great groups of the Ruminants, the *Bovidæ*, *Antilopidæ*, *Camelopardalidæ*, and *Cervidæ*, are represented in the Miocene epoch, and so are the Camels. The Upper-Eocene *Anoplotherium*, which is intercalary between the Pigs and the *Tragulidæ*, has only two or, at most, three toes. Among the scanty mammals of the Lower Eocene formation we have the perissodactyle *Ungulata* represented by *Coryphodon*, *Hyracotherium*, and *Pliolophus*. Suppose for a moment, for the sake of following out the argument, that *Pliolophus* represents the primary stock of the Perissodactyles, and *Dichobune* that of the Artiodactyles (though I am far from saying that such is the case), then we find in the earliest fauna of the Eocene epoch to which our investigations carry us the two divisions of the *Ungulata* completely differentiated, and no trace of any common stock of both or five-toed predecessors to either. With the case of the Horses before us, justifying a belief in the production of new animal forms by modification of old ones, I see no escape from the necessity of seeking for these ancestors of the *Ungulata* beyond the limits of the Tertiary formations.

I could as soon admit special creation, at once, as suppose that the Perissodactyles and Artiodactyles had no five-toed ancestors. And when we consider how large a portion of the Tertiary period elapsed before *Anchitherium* was converted into *Equus*, it is difficult to escape the conclusion that a large proportion of time anterior to the Tertiary must have been expended in converting the common stock of the *Ungulata* into Perissodactyles and Artiodactyles.

The same moral is inculcated by the study of every other order of Tertiary monodelphous *Mammalia*. Each of these orders is represented in the Miocene epoch: the Eocene formation, as I have already said, contains *Chiroptera*, *Insectivora*, *Rodentia*, *Ungulata*, *Carnivora*, and *Cetacea*. But the *Chiroptera* are extreme modifications of the *Insectivora*, just as the *Cetacea* are extreme modifications of the Carnivorous type; and therefore it is to my mind incredible that monodelphous *Insectivora* and *Carnivora* should not have been abundantly developed, along with the *Ungulata*, in the

statement of the chief results of palæontology which I formerly ventured to lay before you.

But the growth of knowledge in the interval makes me conscious of an omission of considerable moment in that statement, inasmuch as it contains no reference to the bearings of palæontology upon the theory of the distribution of life; nor takes note of the remarkable manner in which the facts of distribution, in present and past times, accord with the doctrine of evolution, especially in regard to land animals.

That connexion between palæontology and geology on the one hand, and the present distribution of terrestrial animals, which so strikingly impressed Mr. Darwin thirty years ago as to lead him to speak of a "law of succession of types," and of the wonderful relationship on the same continent between the dead and the living has recently received much elucidation from the researches of Gaudry, of Rütimeyer, of Leidy, and of Alphonse Milne-Edwards, taken in connexion with the earlier labours of our lamented colleague Falconer; and it has been instructively discussed in the thoughtful and ingenious work of Mr. Andrew Murray 'On the Geographical Distribution of Mammals.' [1]

I propose to lay before you, as briefly as I can, the ideas to which a long consideration of the subject has given rise in my own mind.

If the doctrine of evolution is sound, one of its immediate consequences clearly is, that the present distribution of life upon the globe is the product of two factors, the one being the distribution which obtained in the immediately preceding epoch, and the other the character and the extent of the changes which have taken place in physical geography between the one epoch and the other; or, to put the matter in another way, the Fauna and Flora of any given area, in any given epoch, can consist only of such forms of life as are directly descended from those which constituted the Fauna and Flora of the same area in the immediately preceding epoch, unless the physical geography (under which I include climatal conditions) of the area has been so altered as to give rise to immigration of living forms from some other area.

The evolutionist, therefore, is bound to grapple with the following problem whenever it is clearly put before him :—Here are the Faunæ

[1] The paper "On the Form and Distribution of the Land-tracts during the Secondary and Tertiary periods respectively; and on the effect upon Animal Life which great changes in Geographical Configuration have probably produced," by Mr. Searles V. Wood, Jun., which was published in the 'Philosophical Magazine' in 1862, was unknown to me when this Address was written. It is well worthy of the most careful studv.

do not differ greatly in latitude. Thus Falconer and Cautley have made known the fauna of the sub-Himalayas and the Perim Islands; Gaudry that of Attica; many observers that of Central Europe and France; and Leidy that of Nebraska, on the eastern flank of the Rocky Mountains. The results are very striking. The total Miocene fauna comprises many genera and species of Catarrhine Apes, of Bats, of *Insectivora*, of Arctogæal types of *Rodentia*, of *Proboscidea*, of equine, rhinocerotic, and tapirine quadrupeds, of cameline, bovine, antilopine, cervine, and traguline Ruminants, of Pigs and Hippopotamuses, of *Viverridæ* and *Hyænidæ* among other *Carnivora*, with *Edentata* allied to the Arctogæal *Orycteropus* and *Manis*, and not to the Austro-Columbian Edentates. The only type present in the Miocene, but absent in the existing fauna of Eastern Arctogæa, is that of the *Didelphidæ*, which, however, remains in North America.

But it is very remarkable that while the Miocene fauna of the Arctogæal province, as a whole, is of the same character as the existing fauna of the same province, as a whole, the component elements of the fauna were differently associated. In the Miocene epoch, North America possessed Elephants, Horses, Rhinoceroses, and a great number and variety of Ruminants and Pigs, which are absent in the present indigenous fauna; Europe has its Apes, Elephants, Rhinoceroses, Tapirs, Musk-deer, Giraffes, Hyænas, great Cats, Edentates and Opossum-like Marsupials, which have equally vanished from its present fauna; and in Northern India, the African types of Hippopotamuses, Giraffes, and Elephants were mixed up with what are now the Asiatic types of the latter, and with Camels and Semnopithecine and Pithecine Apes of no less distinctly Asiatic forms.

In fact the Miocene mammalian fauna of Europe and the Himalayan regions contains, associated together, the types which are now separately located in the South African and Indian subprovinces of Arctogæa. Now there is every reason to believe, on other grounds, that both Hindostan, south of the Ganges, and Africa, south of the Sahara, were separated by a wide sea from Europe and North Asia during the Middle and Upper Eocene epochs. Hence it becomes highly probable that the well-known similarities, and no less remarkable differences, between the present Faunæ of India and South Africa have arisen in some such fashion as the following. Some time during the Miocene epoch, possibly when the Himalayan chain was elevated, the bottom of the nummulitic sea was upheaved and converted into dry land, in the direction of a line extending from Abyssinia to the mouth of the Ganges. By this means, the Dekhan on the one hand, and South Africa on the other, became connected

mammal (*Homalodotherium*) which Dr. Cunningham sent over to me some time ago from Patagonia. I confess I am strongly inclined to surmise that these last, at any rate, are remnants of the population of Austro-Columbia before the Miocene epoch, and were not derived from Arctogæa by way of the north and east.

The fact that this immense fauna of Miocene Arctogæa is now fully and richly represented only in India and South Africa, while it is shrunk and depauperised in North Asia, Europe, and North America, becomes at once intelligible, if we suppose that India and South Africa had but a scanty mammalian population before the Miocene immigration, while the conditions were highly favourable to the new comers. It is to be supposed that these new regions offered themselves to the Miocene Ungulates, as South America and Australia offered themselves to the cattle, sheep, and horses of modern colonists. But, after these great areas were thus peopled, came the Glacial epoch, during which the excessive cold, to say nothing of depression and ice-covering, must have almost depopulated all the northern parts of Arctogæa, destroying all the higher mammalian forms except those which, like the Elephant and Rhinoceros, could adjust their coats to the altered conditions. Even these must have been driven away from the greater part of the area; only those Miocene mammals which had passed into Hindostan and into South Africa would escape decimation by such changes in the physical geography of Arctogæa. And when the northern hemisphere passed into its present condition, these lost tribes of the Miocene Fauna were hemmed by the Himalayas, the Sahara, the Red Sea, and the Arabian deserts within their present boundaries.

Now, on the hypothesis of evolution, there is no sort of difficulty in admitting that the differences between the Miocene forms of the mammalian Fauna and those which exist now are the results of gradual modification; and, since such differences in distribution as obtain are readily explained by the changes which have taken place in the physical geography of the world since the Miocene epoch, it is clear that the result of the comparison of the Miocene and present Faunæ is distinctly in favour of evolution. Indeed I may go further. I may say that the hypothesis of evolution explains the facts of Miocene, Pliocene, and Recent distribution, and that no other supposition even pretends to account for them. It is, indeed, a conceivable supposition that every species of Rhinoceros and every species of Hyæna, in the long succession of forms between the Miocene and the present species, was separately constructed out of

There is nothing, then, in what is known of the older Eocene mammals of the Arctogæal province to forbid the supposition that they stood in an ancestral relation to those of the Calcaire Grossier and the Gypsum of the Paris basin, and that our present fauna, therefore, is directly derived from that which already existed in Arctogæa at the commencement of the Tertiary period. But if we now cross the frontier between the Cainozoic and the Mesozoic faunæ, as they are preserved within the Arctogæal area, we meet with an astounding change, and what appears to be a complete and unmistakable break in the line of biological continuity.

Among the twelve or fourteen species of *Mammalia* which are said to have been found in the Purbecks, not one is a member of the orders *Chiroptera*, *Rodentia*, *Ungulata*, or *Carnivora*, which are so well represented in the tertiaries. No *Insectivora* are certainly known, nor any opossum-like Marsupials. Thus there is a vast negative difference between the Cainozoic and the Mesozoic mammalian faunæ of Europe. But there is a still more important positive difference, inasmuch as all these Mammalia appear to be Marsupials belonging to Australian groups and thus appertaining to a different distributional province from the Eocene and Miocene marsupials, which are Austro-Columbian. So far as the imperfect materials which exist enable a judgment to be formed, the same law appears to have held good for all the earlier Mesozoic *Mammalia*. Of the Stonesfield slate mammals, one, *Amphitherium*, has a definitely Australian character; one, *Phascolotherium*, may be either Dasyurid or Didelphine; of a third, *Stereognathus*, nothing can at present be said. The two mammals of the Trias, also, appear to belong to Australian groups.

Every one is aware of the many curious points of resemblance between the marine fauna of the European Mesozoic rocks and that which now exists in Australia. But if there was this Australian facies about both the terrestrial and the marine faunæ of Mesozoic Europe, and if there is this unaccountable and immense break between the fauna of Mesozoic and that of Tertiary Europe, is it not a very obvious suggestion that, in the Mesozoic epoch, the Australian province included Europe, and that the Arctogæal province was contained within other limits? The Arctogæal province is at present enormous, while the Australian is relatively small. Why should not these proportions have been different during the Mesozoic epoch?

Thus I am led to think that by far the simplest and most rational mode of accounting for the great change which took place in the living inhabitants of the European area at the end of the Mesozoic

Australian side just as the Eocene mammals differ from those of the Purbecks.

How do similar reasonings apply to the other great change of life —that which took place at the end of the Palæozoic period?

In the Triassic epoch, the distribution of the dry land and of terrestrial vertebrate life appears to have been, generally, similar to that which existed in the Mesozoic epoch; so that the Triassic continents and their faunæ seem to be related to the Mesozoic lands and their faunæ, just as those of the Miocene epoch are related to those of the present day. In fact, as I have recently endeavoured to prove to the Society, there was an Arctogæal continent and an Arctogæal province of distribution in Triassic times as there is now; and the *Sauropsida* and *Marsupialia* which constituted that fauna were, I doubt not, the progenitors of the *Sauropsida* and *Marsupialia* of the whole Mesozoic epoch.

Looking at the present terrestrial fauna of Australia, it appears to me to be very probable that it is essentially a remnant of the fauna of the Triassic, or even of an earlier, age;[1] in which case Australia must at that time have been in continuity with the Arctogæal continent.

But now comes the further inquiry. Where was the highly differentiated Sauropsidan fauna of the Trias in Palæozoic times? The supposition that the Dinosaurian, Crocodilian, Dicynodontian, and Plesiosaurian types were suddenly created at the end of the Permian epoch may be dismissed, without further consideration, as a monstrous and unwarranted assumption. The supposition that all these types were rapidly differentiated out of *Lacertilia*, in the time represented by the passage from the Palæozoic to the Mesozoic formation, appears to me to be hardly more credible, to say nothing of the indications of the existence of Dinosaurian forms in the Permian rocks which have already been obtained.

For my part, I entertain no sort of doubt that the Reptiles, Birds, and Mammals of the Trias are the direct descendants of Reptiles, Birds, and Mammals which existed in the latter part of the Palæozoic epoch, but not in any area of the present dry land which has yet been explored by the geologist.

This may seem a bold assumption, but it will not appear unwarrantable to those who reflect upon the very small extent of the earth's surface which has hitherto exhibited the remains of the great

[1] Since this Address was read, Mr. Krefft has sent us news of the discovery in Australia of a freshwater fish of strangely Palæozoic aspect, and apparently a Ganoid intermediate between *Dipterus* and *Lepidosiren*.

South American or Australian continent, and, in course of time, it would be peopled by an extension of the fauna of one of these two regions—just as I imagine the European Permian dry land to have been peopled.

I see nothing whatever against the supposition that distributional provinces of terrestrial life existed in the Devonian epoch, inasmuch as M. Barrande has proved that they existed much earlier. I am aware of no reason for doubting that, as regards the grades of terrestrial life contained in them, one of these may have been related to another as New Zealand is to Australia, or as Australia is to India, at the present day. Analogy seems to me to be rather in favour of, than against, the supposition that while only Ganoid fishes inhabited the fresh waters of our Devonian land, *Amphibia* and *Reptilia*, or even higher forms, may have existed, though we have not yet found them. The earliest Carboniferous *Amphibia* now known, such as *Anthracosaurus*, are so highly specialized that I can by no means conceive that they have been developed out of piscine forms in the interval between the Devonian and the Carboniferous periods, considerable as that is. And I take refuge in one of two alternatives: either they existed in our own area during the Devonian epoch and we have simply not yet found them, or they formed part of the population of some other distributional province of that day, and only entered our area by migration at the end of the Devonian epoch. Whether *Reptilia* and *Mammalia* existed along with them is to me, at present, a perfectly open question, which is just as likely to receive an affirmative as a negative answer from future inquirers.

Let me now gather together the threads of my argumentation into the form of a connected hypothetical view of the manner in which the distribution of living and extinct animals has been brought about.

I conceive that distinct provinces of the distribution of terrestrial life have existed since the earliest period at which that life is recorded, and possibly much earlier; and I suppose, with Mr. Darwin, that the progress of modification of terrestrial forms is more rapid in areas of elevation than in areas of depression. I take it to be certain that Labyrinthodont *Amphibia* existed in the distributional province which included the dry land depressed during the Carboniferous epoch; and I conceive that, in some other distributional provinces of that day, which remained in the condition of stationary or of increasing dry land, the various types of the terrestrial *Sauropsida* and of the *Mammalia* were gradually developing.

The Permian epoch marks the commencement of a new movement of upheaval in our area, which attained its maximum in the

XXXI

ON THE ETHNOLOGY OF BRITAIN

The Journal of the Ethnological Society of London, New Series, vol. ii., 1870, *pp.* 382–384. (*Read May* 10*th*, 1870.)

THE President commenced his observations by a reference to the earliest information given by ancient writers concerning the inhabitants of these Islands. This information relates partly to the physical characters of the natives, and partly to their language. Much unnecessary confusion has arisen from not keeping these two subjects distinct from each other; and, in accordance with Professor Max Müller, the President strongly insisted on the necessity of pursuing the study of language apart from that of the physical characters of a people.

Julius Cæsar, like many other men of his time, is somewhat reticent on such subjects; but Tacitus, who wrote a century later, gives much fuller information. These early accounts show that probably in the time of Cæsar, and certainly in that of Tacitus, there existed in these islands two distinct types of population:—the one of tall stature, with fair skin, yellow hair, and blue eyes; the other of short stature, with dark skin, dark hair, and black eyes. We further learn that this dark population, represented by the Silures, bore considerable physical resemblance to the people of Aquitania and Iberia; while the fair population of parts of South-East Britain—the present counties of Kent and Hants—resembled the Belgæ who inhabited the North-East of France and the country now called Belgium. These Belgæ, again, were closely akin in physical characters to the tall fair people who dwelt on the east bank of the Rhine, and were called Germani.

These two distinct ethnological elements probably coexisted in

ancient population of Aquitania and Iberia. There we have a large area occupied by the Basques or Euskarians, who speak a language which has no affinity with any other known Eur-Asiatic language. At the present day the Euskarian area has been so largely encroached upon that it is reduced to a portion of its primitive dimensions. And it is to this circumstance, possibly, that we must ascribe the fact that a large proportion of the modern Basques are fair people. Looking at the characters of the present inhabitants of the old Euskarian area, however, it can hardly be doubted that the Euskarian-speaking people were essentially dark. Thus, on the Continent there were two types of people speaking distinct languages, while in Britain there were two corresponding types speaking one common language.

Considerable changes in this language, however, were consequent upon the foreign invasions. The Saxon invaders brought with them their Teutonic dialects; and these to a great extent supplanted the preexisting Celtic. Hence at the time of the Norman conquest, Celtic was but little spoken in the east and southern parts; but it long retained its place in Wales, Cornwall, and the western parts of England. At the end of the tenth, or beginning of the eleventh century, we had therefore a primitive population, consisting of the dark stock in the west and the fair in the east, the latter replaced to some extent by another fair stock speaking a different language. Such was the state of the country at the period of the Norman invasion.

commences the following letter, which I received from him three days afterwards, by an allusion to this circumstance:—

Ore House, near Hastings,
May 28, 1868.

MY DEAR SIR,—Dr. R. King writes to inform me that, after consulting with his friends in the Ethnological Society, it was thought best not to make any proposal at the Meeting on Tuesday. It was thought best that such a resolution should come from the Council. On the whole there is no reason to regret this; but, after our conversation last week, I have thought it my duty to write to inform you why the subject was not brought before the Society, as I believed (when I had the pleasure of seeing you) would have been done.

Col. Lane Fox writes to me, to say that he has suggested to you the desirability of having a department for 'Prehistoric archæology, as he translates "*Paléo-anthropologie.*" With reference to this suggestion, I may mention that last year I prepared a scheme for a union of the two Societies on such a basis.

This question is, however, worth discussing, and I think at some future time such a scheme might be worthy of full consideration.

On the whole, however, I do not think such a scheme is at present either practicable or desirable. I think it is a great pity to separate the different branches of the same science. The Geological Society is an instance of the good effect of the union of different branches of one large science.

I shall be in London on Tuesday next, and if you would ere then consult with your friends, I shall be ready to call on you at 12 o'clock on that day. If there is any chance of a union being effected, I can then bring the subject before our Council the same afternoon. I mention this because I go away for my vacation the end of June. I think that if a union can be effected, it should be decided on before the meeting of the Association at Norwich, in August. If this is to be done, the subject must be discussed at once. We usually print our cards for each year's meetings in July, and this is another reason why action should be taken in the matter at once, or the whole subject left over until the beginning of the next Session or next year. I have been trying to effect this union for the last five or six years, and as I firmly believe that the longer it is delayed the better will it be for my own wishes, I shall not raise any objections to a delay in this matter.

Both Societies will soon have to give up their rooms at 4, St. Martin's Place, and we each have to give six months' notice. We may

In reference to proposal No. V., I had better explain that we cannot at present say how our finances will stand at the end of the year. Our defaulters' list amounts to far more than our debts, and we have a stock of translations. If these books are suddenly thrown on the market, we shall get little for them, and there may be a loss—hence the insertion of this proposal.

I am alone responsible for these proposals. In drawing them up I have only been guided by a desire to suggest what is practicable.

I shall myself enter into negotiations for the union solely anxious to make the best and most useful Society we can. I do not think that there are two interests in such a matter.

If you think it advisable to propose that the future Council shall consist of an equal number of each existing councils, or to suggest any other proposals based on scientific considerations, I shall be very glad to discuss the same.

Believe me,

Yours very faithfully,

JAMES HUNT.

PROFESSOR HUXLEY, F.R.S.

Dr. Hunt's Proposals.

Preliminary Terms of Union, which have received the sanction of the Presidents of the Ethnological and Anthropological Societies, and submitted by them to their respective Councils.

I. That it is highly desirable in the interests of science, that the Ethnological and Anthropological Societies should be united.

II. That with a view to effect such union, a Committee of SIX (*three*) Members of each Council be nominated to draw up terms of union and regulations, ***and nominate Officers and Council.***

III. That on receipt of such terms of union and regulations, by the respective Presidents of the two Societies, a General Meeting of each Society shall be called within fourteen days to consider the same.

IV. That, with a view of facilitating the proposed amalgamation, and of removing obstacles from its accomplishment, the Committee be instructed to base the rules of the United Society, as far as possible, on those of the Ethnological Society; while the NAME OF THE United Society BE ASSIMILATED TO THAT OF (*adopt the name of*) the Anthropological Society, ***unless a better can be found.***

the Ethnological Council; and that, in fact, I could not go to the Ethnological Council with a proposition so worded.

We nearly came to a dead lock upon this point; and the difficulty was only got over by Dr. Hunt's acceptance of my suggestion, to add the words "unless a better can be found."

I fully explained to Dr. Hunt why I chose this form of words. I imagined (and I must confess I still imagine) that reasonable men upon both sides would see that "the best name which could be found" would be one which would enable the Societies to unite; and that any name which should be an obstacle to that union would be *ipso facto* not "the best name which could be found."

Dr. Hunt was perfectly well aware that these words were added on no other ground than the strong objection entertained by Members of the Council of the Ethnological Society to the adoption of the name of the Anthropological Society.

A Meeting of the Council of the Ethnological Society was held on the 9th of June, having been summoned as soon as I knew that the propositions, as amended, had been agreed to by the Council of the Anthropological Society.

It will be observed that the propositions are silent respecting any confirmation of the acts of the delegates by the respective Councils. Both Dr. Hunt and I agreed that it would be better that the Councils should give their delegates full powers; but it was obviously impossible that either he, or I, should do more than attempt to bring this about.

In my case the Council required the delegates to report and receive confirmation of their acts, while the Anthropological Council gave its delegates full powers.

Under these circumstances, I felt bound to put our position clearly before Dr. Hunt, before the meeting of the delegates took place. I did so in the following letter, dated the 10th (not 11th) June 1868, in order that Dr. Hunt might judge for himself how far the understanding between us had been kept; and that if he were dissatisfied, he might say so.

Jermyn Street,
June 10, 1868.

MY DEAR SIR,—I had no time to write to you yesterday after the meeting of the Council of the Ethnological Society, but I gave Mr. Collingwood a copy of the Resolution which the Council passed, the names of the Committee-men appointed, and the day and hour of meeting, viz., to-morrow (Thursday, 11th of June) at 4 P.M.

After the meeting I wrote to Dr. Hunt as follows:—

26 Abbey Place, N.W.,
June 15, 1868.

MY DEAR SIR,—I am glad to be able to inform you that at the meeting of the Council of the Ethnological Society to-day, Major-General Balfour, Mr. Hyde Clarke, and myself were furnished with full power to arrange the terms of union of the Ethnological and Anthropological Societies, and to organize the resulting new Society under the title of "The Society for the Promotion of the Science of Man."

We have arranged with Mr. Braybrook to meet your Committee at 5 o'clock to-morrow afternoon, in order to arrive at a final settlement with respect to sundry points which still require discussion.

I am, yours very faithfully,
T. H. HUXLEY.

DR. HUNT,
President of the Anthropological Society.

It will be obvious, from the tone of this letter, that I imagined the business was practically settled, the "sundry points which still require discussion" being matters of detail about which I was sure that our side would make no difficulty.

But when our meeting took place, the delegates of the Anthropological Society placed in our hands a resolution just passed by the Council, which rejected the one stipulation upon which the delegates of both sides had absolutely agreed.

The Council of the Anthropological Society had, undoubtedly, a legal right to act in this manner; but that it did thus, without any provocation on our part, break off a treaty which we considered to be virtually concluded, is clear; and that it disavowed the acts of its delegates is perfectly obvious from the fact that Dr. Hunt and Mr. Braybrook thought right to resign their offices.

Considering the circumstances under which the negotiations were broken off by the Council of the Anthropological Society, the Council of the Ethnological Society could hardly take the initiative in any further movement towards amalgamation, though they have always expressed the utmost readiness to re-open the negotiations. However, when Dr. Beddoe, the present President of the Anthropological Society, was elected, I thought the opportunity a good one for bringing the state of affairs privately under his notice, and I

one who can devote to its duties the time and the attention they deserve.

I hope, therefore, that it is quite clear that I have no personal interest to serve in advocating amalgamation.

I am, yours very faithfully,
T. H. HUXLEY.

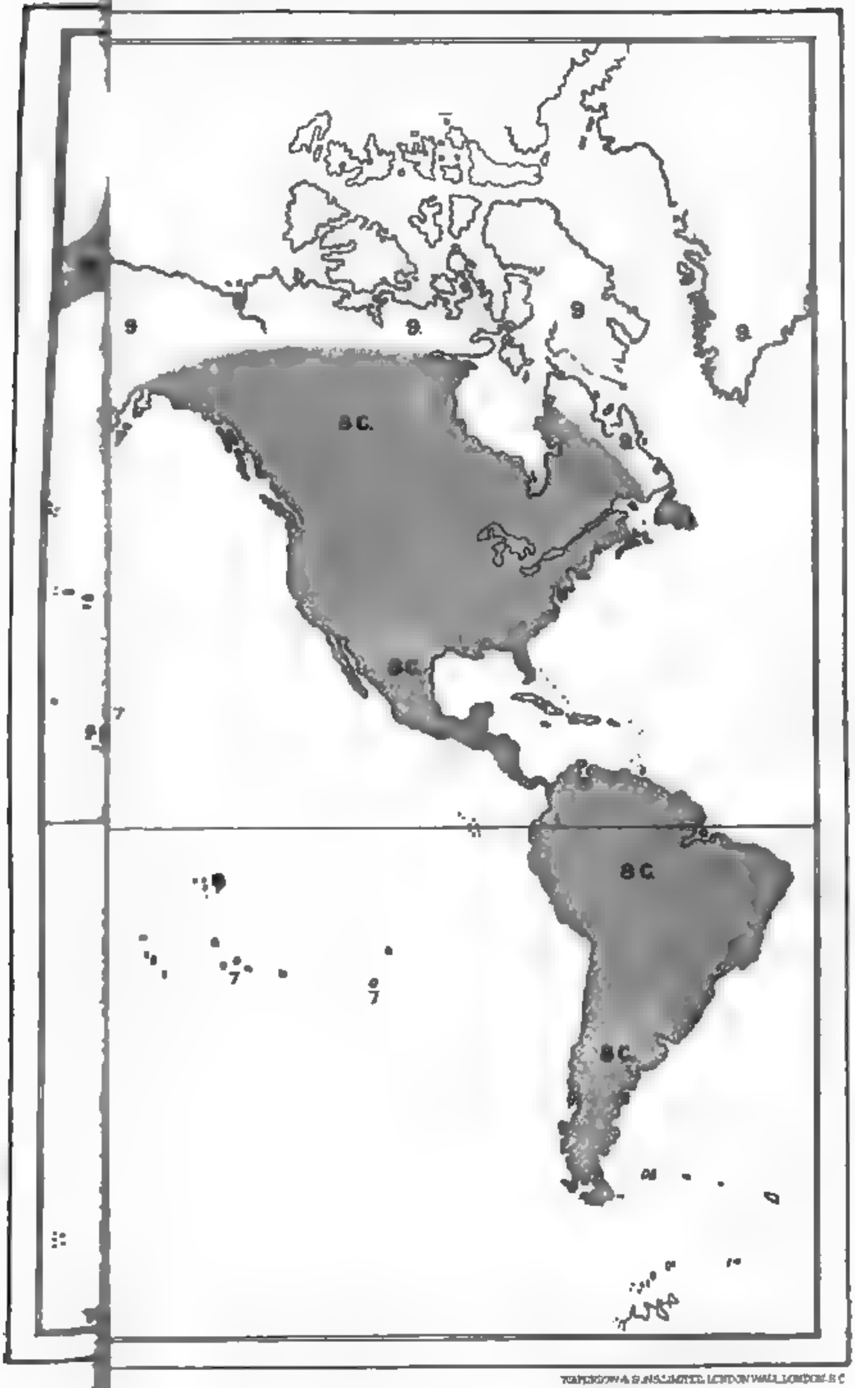
DR. BEDDOE,
President of the Anthropological Society.

I received a courteous reply from Dr. Beddoe, expressive of general good-will; but I am not aware that any other result has followed my communication. On our side we are ready and willing, as we always have been, to discuss terms of union.

So much for an earnest but fruitless endeavour to bring about an amalgamation directly with the Anthropological Society. But it may be worthy of consideration whether it is wise thus to limit our efforts. The Anthropological Society is only one of several Societies, the spheres of activity of which all more or less coincide with those of the Ethnological Society. For example, I need only name the Society of Antiquaries, the Archæological Institute, the Archæological Association, and the Geographical Society. The loss of time, money, and energy involved in the absence of any cooperation or harmonious action among these Societies in respect of the ground common to all of them is very lamentable, and I should be very glad to see something done to prevent the occurrence of this waste in future.

I am glad to be able to inform you that, in accordance with the practice which has now prevailed for some years, ample provision has been made for the full representation of Ethnological and Anthropological science at the meeting of the British Association for the Advancement of Science, at Liverpool, in September next; and I trust that the Department of Section D, which will meet under the Presidency of Mr. J. Evans, F.R.S., will be well supplied with papers.

ND ACCORDING TO PROF^R HUXLEY.



marked alveolar prognathism. The teeth are large, and the fangs usually stronger and more distinctly marked than in other forms of mankind. The outlet of the male pelvis is remarkably narrow.

These characters are common to all the inhabitants of Australia proper (excluding Tasmania); and the only notable differences I have observed are that, in some Australians, the calvaria is high and wall-sided, while in others it is remarkably depressed. No skulls are, in general, so easily recognizable as fair examples of those of the Australians, though those of their nearest neighbours, the inhabitants of the Negrito Islands, are frequently hardly distinguishable from them.

The only people out of Australia who present the chief characteristics of the Australians in a well-marked form are the so-called hill-tribes who inhabit the interior of the Dekhan, in Hindostan. An ordinary Coolie, such as may be seen among the crew of any recently returned East-Indiaman, if he were stripped to the skin, would pass muster very well for an Australian, though he is ordinarily less coarse in skull and jaw.

In the accompanying map, therefore, the deep blue colour (No. 5) is given not only to Australia, but to the interior of the Dekhan. A lighter tint of the same colour occupies the area inhabited by the ancient Egyptians and their modern descendants. For, although the Egyptian has been much modified by civilization and probably by admixture, he still retains the dark skin, the black, silky, wavy hair, the long skull, the fleshy lips, and broadish alæ of the nose which we know distinguished his remote ancestors, and which cause both him and them to approach the Australian and the "Dasyu" more nearly than they do any other form of mankind.

It is a most remarkable circumstance that no trace of the Australioid type has been found in any of the islands of the Malay archipelago, all the dark-skinned people who occur in some of these islands and in the Andamans being Negritos. On the other hand, no Negroid type is known to occur between the Andamans and East Africa, the darker elements of the Southern Arabian population being Australioid rather than Negroid.

II. The Negroid Type (Nos. 1, 2, 3).

As the chief representative of the Australioid type is the Australian of Australia, so is that of the Negroid type the Negro of South Africa (including Madagascar) between the Sahara and what may be roughly called the region of the Cape.

considerable intermixture with the Polynesians; and it seems probable that a similar crossing with Malays may have occurred in New Guinea.

III. The Xanthochroic Type (No. 6).

A third extremely well-defined type of mankind is exhibited by the greater part of the population of Central Europe. These are the Xanthochroi, or fair whites. They are of tall stature and have the skin almost colourless, and so delicate that the blood really shows through it. The eyes are blue or grey; the hair light, ranging from straw-colour to red or chestnut; the beard and body-hair abundant. The skull presents all varieties of forms, from extreme dolichocephaly to extreme brachycephaly. On the south and west this type comes into contact and mixes with the "Melanochroi," or "dark whites," while on the north and east it becomes mingled with the people of Mongoloid type, who bound it on that side. Its extreme north-west limit is Iceland; its south-west limit the Canary Islands; its south border lies in Africa north of the Sahara, in Syria, and Northern Arabia; its south-eastern limit is Hindostan; while in a north-easterly direction traces of it have been observed as far eastward as the Yenisei. I have not ventured, however, to draw the red bars which indicate the existence of this type, alongside of another, so far to the east, as one really knows very little about the people of Central Asia.

IV. The Mongoloid Type (No. 8).

An enormous area, which lies mainly to the east of a line drawn from Lapland to Siam, is peopled, for the most part, by men who are short and squat, with the skin of a yellow-brown colour; the eyes and hair black, and the latter straight, coarse, and scanty on the body and face, but long on the scalp. They are strongly brachycephalic, the skull being usually devoid of prominent brow-ridges, while the nose is flat and small, and the eyes are oblique. The Malays proper, and, I suspect, the indigenous people of the Philippines who are not Negritos, fall under the same general definition.

On the other hand, the Chinese and Japanese, in whom the skin, hair, nose, and eyes are like those of the Mongoloids just mentioned, are dolichocephalic; and the Ainos, also dolichocephalic, are distinguished for the extraordinary development of hair on their faces and bodies.

The Dyaks of the interior of Borneo are likewise dolichocephalic; and these people, and the Battaks of Sumatra, the so-called Alfurus

in the huge Americo-Asiatic area, as in the only less vast space occupied by the Polynesian islands, it is possible to find every gradation between the extreme terms.

The four great groups of mankind, the areas of which have now been defined, occupy the whole world, with the exception of western and southern Europe, cis-Saharal Africa, Asia Minor, Syria, Arabia, Persia, and Hindostan. In these regions are found, more or less mixed with Xanthochroi and Mongoloids, and extending to a greater or less distance into the conterminous Xanthochroic, Mongoloid, Negroid, and Australioid areas, the men whom I have termed MELANOCHROI, or dark whites. Under its best form this type is exhibited by many Irishmen, Welshmen, and Bretons, by Spaniards, South Italians, Greeks, Armenians, Arabs, and high-caste Brahmins. A man of this group may, in point of physical beauty and intellectual energy, be the equal of the best of the Xanthochroi: but he presents a great contrast, in other respects, to the latter type; for the skin, though clear and transparent, is of a more or less brown hue, deepening to olive, the hair, fine and wavy, is black, and the eyes are of a like hue. The average stature, however, is ordinarily lower than in the Xanthochroic type, and the make of the frame is usually lighter. In Hindostan the Melanochroi pass by innumerable gradations into the Australioid type of the Dekhan, while in Europe they shade off by endless varieties of intermixture into the Xanthochroi.

I have great doubts if the Melanochroi are to be regarded as a primitive modification of mankind in the sense in which that term applies to the Australioids, Negroids, Mongoloids, and Xanthochroi. On the contrary, I am much disposed to think that the *Melanochroi* are the result of an intermixture between the Xanthochroi and the Australioids. It is to the Xanthochroi and Melanochroi, taken together, that the absurd denomination of "Caucasian" is usually applied.

Perhaps the most interesting fact which comes into prominence in the map of the distribution of these great groups of mankind, is the contrast between the broad and general uniformity which prevails over such an enormous area, exhibiting every diversity of climate and physical conditions, as that of the two Americas, and the singular variety crowded into a relatively small area elsewhere, as, for example, in the Pacific. Here, if we follow one and the same zone of latitude for a few thousand miles of longitude from east to west, we pass from Polynesian Mongoloids, in the Navigators, or the Friendly Islands, to Negritos in the New Hebrides, and to Australioids on the mainland of Australia.

that when that breed was first developed it was in the form of a Jewish-looking man. He then supposed, as Professor Huxley seemed to suppose, that these true Caucasians descending towards the south and mixing with Australioids became Hindoos, that in Southern Arabia mixing with some other race they became those Arabs whom Palgrave describes as more like Southern Hindoos than Northern Arabs.. Again, descending to the north-west into Europe, he believed that our Caucasian fathers intermixed with some primitive races of cockle-eaters and such like, who (through our great-great-grandmothers) shortened our noses, detracted from our beauty, and rendered us the mixed and varied race that we now are. In fact, instead of distinguishing the peoples of Europe and Western Asia into Xanthochroi and Melanochroi, he would distinguish them into perfect and imperfect Caucasians. On the subject of skulls, while they might be one of the marks to distinguish very primitive races, Professor Huxley's statements had pretty well demolished them as a safe test of more advanced races, since he had shown that races otherwise very similar had very wide diversities of skull, *e.g.* the Tartars and Chinese among the Mongols—and, above all, the European peoples, any assembly of whom presented every form of skull. With respect to the predominance of round skulls in certain parts of Europe, he would suggest that possibly those were the parts which had been most mixed with round-headed Tartars or Mongols. In the part indicated by Professor Huxley there had been the great Hungarian invasions; and generally it might be said that the Mongol races had spread westwards in later times, and come more into contact with the Slavonians and later tribes of Europe, while our Norman and Saxon progenitors, being an earlier wave of immigration, had not so much mixed with Asiatic Tartars.

Mr. ALFRED R. WALLACE said that, as a small contribution to the subject, he would venture to point out that there were certain mental characteristics which in two at least of the primary groups were as well marked and as constant as the physical characters by which Professor Huxley had defined them. The great Mongoloid group, for instance, was distinguished by a general gravity of demeanour and concealment of the emotions, by deliberation of speech, and the absence of violent gesticulation, by the rarity of laughter, and by plaintive and melancholy songs. The tribes composing it were pre-eminently apathetic and reserved; and this character was exhibited to a high degree in the North-American Indian, and in all the Malay races, and to a somewhat less extent over the whole of the enormous area occupied by the Mongoloid type. Strongly contrasted with these were the Negroid group, whose characteristics were vivacity and excitability, strong exhibitions of feeling, loud and rapid speech, boisterous laughter, violent gesticulations, and rude, noisy music. They were preeminently impetuous and demonstrative; and this feature was seen fully developed both in the African Negro and in the widely removed Papuan of New Guinea. This striking correspondence of mental with physical characters strongly supported the view that these two at least were among the best-marked primary divisions of our race.

The only point on which he ventured to differ from the classification of Professor Huxley was as to the position to be assigned to the brown Polynesians. These, as typically represented by the Tahitians, appeared to him to be much more nearly related to the Papuans than to the Malays, and should therefore be classed as Negroid instead of Mongoloid. In all important physical characters, except colour, they agreed with the former; and the general testimony of travellers, from Cook downwards, showed that their mental characteristics were entirely Negroid, as evinced by their vivacity, demonstrativeness, and laughter. At the same time there was no doubt a large infusion of Malay blood; but that this was for the most part a comparatively recent event was shown by the language, which retained a number of Malay terms almost unchanged. He maintained therefore that the typical Polynesians were fundamentally Negroid with a considerable Mongoloid intermixture, and not originally Mongoloid with a Negroid intermixture.

Mr. LUKE BURKE maintained that differences in the colour of the skin and hair, and in the relative proportions of the skull, were only of trivial value, and should not be taken as a basis in defining the primary divisions of the human race.

It is a matter of every day experience that it is difficult to prevent many articles of food from becoming covered with mould; that fruit, sound enough to all appearance, often contains grubs at the core; that meat, left to itself in the air, is apt to putrefy and swarm with maggots. Even ordinary water, if allowed to stand in an open vessel, sooner or later becomes turbid and full of living matter.

The philosophers of antiquity, interrogated as to the cause of these phenomena, were provided with a ready and a plausible answer. It did not enter their minds even to doubt that these low forms of life were generated in the matters in which they made their appearance. Lucretius, who had drunk deeper of the scientific spirit than any poet of ancient or modern times except Goethe, intends to speak as a philosopher, rather than as a poet, when he writes that "with good reason the earth has gotten the name of mother, since all things are produced out of the earth. And many living creatures, even now, spring out of the earth, taking form by the rains and the heat of the sun."[1] The axiom of ancient science, "that the corruption of one thing is the birth of another," had its popular embodiment in the notion that a seed dies before the young plant springs from it; a belief so widespread and so fixed, that Saint Paul appeals to it in one of the most splendid outbursts of his fervid eloquence:—

"Thou fool, that which thou sowest is not quickened, except it die."[2]

The proposition that life may, and does, proceed from that which has no life, then, was held alike by the philosophers, the poets, and the people, of the most enlightened nations, eighteen hundred years ago; and it remained the accepted doctrine of learned and unlearned Europe, through the Middle Ages, down even to the seventeenth century.

It is commonly counted among the many merits of our great countryman Harvey, that he was the first to declare the opposition of fact to venerable authority in this, as in other matters; but I can discover no justification for this widespread notion. After careful search through the 'Exercitationes de Generatione,' the most that appears clear to me is, that Harvey believed all animals and plants to spring

[1] It is thus that Mr. Munro renders:—

"Linquitur, ut merito maternum nomen adepta
Terra sit, e terra quoniam sunt cuncta creata.
Multaque nunc etiam exsistunt animalia terris
Imbribus et calido solis concreta vapore."

DE RERUM NATURA, lib. v. 793—796.

But would not the meaning of the last line be better rendered "Developed in rain-water and in the warm vapours raised by the sun?"

[2] 1 Corinthians xv. 36.

in the dead flesh; but if I put similar bodies, while quite fresh, into a jar, and tie some fine gauze over the top of the jar, not a maggot makes its appearance, while the dead substances, nevertheless, putrefy just in the same way as before. It is obvious, therefore, that the maggots are not generated by the corruption of the meat; and that the cause of their formation must be a something which is kept away by gauze. But gauze will not keep away aëriform bodies, or fluids. This something must, therefore, exist in the form of solid particles too big to get through the gauze. Nor is one long left in doubt what these solid particles are; for the blowflies, attracted by the odour of the meat, swarm round the vessel and, urged by a powerful but, in this case, misleading instinct, lay eggs, out of which maggots are immediately hatched, upon the gauze. The conclusion, therefore, is unavoidable; the maggots are not generated by the meat, but the eggs which give rise to them are brought through the air by the flies.

These experiments seem almost childishly simple, and one wonders how it was that no one ever thought of them before. Simple as they are, however, they are worthy of the most careful study, for every piece of experimental work since done, in regard to this subject, has been shaped upon the model furnished by the Italian philosopher. As the results of his experiments were the same, however varied the nature of the materials he used, it is not wonderful that there arose in Redi's mind a presumption, that in all such cases of the seeming production of life from dead matter, the real explanation was the introduction of living germs from without into that dead matter.[1]

[1] "Pure contentandomi sempre in questa ed in ciascuna altra cosa, da ciascuno più savioi là dove io difettuosamente parlassi, esser corretto; non tacero, che per molte osservazion molti volti da me fatte, mi sento inclinato a credere che la terra, da quelle prime piante, e da quei primi animali in poi, che ella nei primi giorni del mondo produsse per comandemento del sovrano ed omnipotente Fattore, non abbia mai più prodotto da se medesima nè erba nè albero, nè animale alcuno perfetto o imperfetto che ei se fosse; e che tutto quello, che ne' tempi trapassati è nato e che ora nascere in lei, o da lei veggiamo, venga tutto dalla semenza reale e vera delle piante, e degli animali stessi, i quali col mezzo del proprio seme la loro spezie conservano. E se bene tutto giorno scorghiamo da' cadaveri degli animali, e da tutte quante le maniere dell' erbe, e de' fiori, e dei frutti imputriditi, e corrotti nascere vermi infiniti—

Nonne vides quæcunque mora, fluidoque calore
Corpora tabescunt in parva animalia verti—

Io mi sento, dico, inclinato a credere che tutti quei vermi si generino dal seme paterno; e che le carni, e l'erbe, e l'altre cose tutte putrefatte, o putrefattibili non facciano altra parte, nè abbiano altro ufizio nella generazione degl' insetti, se non d'apprestare un luogo o un nido proporzionato, in cui dagli animali nel tempo della figliatura sieno portati, e partoriti i vermi, o l'uova, o l'altre semenze dei vermi, i quali tosto che nati sono, trovano in esso nido un sufficiente alimento abilissimo per nutricarsi: e se in quello non son portate dalle madri queste suddette semenze, niente mai, e replicatamente niente, vi s'ingegneri e nasca."—REDI, *Esperienze*, pp. 14-16.

It is of great importance to apprehend Redi's position rightly; for the lines of thought he laid down for us are those upon which naturalists have been working ever since. Clearly, he held *Biogenesis* as against *Abiogenesis*; and I shall immediately proceed, in the first place, to inquire how far subsequent investigation has borne him out in so doing.

But Redi also thought that there were two modes of Biogenesis. By the one method, which is that of common and ordinary occurrence, the living parent gives rise to offspring which passes through the same cycle of changes as itself—like gives rise to like; and this has been termed *Homogenesis*. By the other mode, the living parent was supposed to give rise to offspring which passed through a totally different series of states from those exhibited by the parent, and did not return into the cycle of the parent: this is what ought to be called *Heterogenesis*, the offspring being altogether, and permanently, unlike the parent. The term Heterogenesis, however, has unfortunately been used in a different sense, and M. Milne-Edwards has therefore substituted for it *Xenogenesis*, which means the generation of something foreign. After discussing Redi's hypothesis of universal

l'alimento, col rodere ci aprono la strada, ed arrivano alla più interna midolla de' frutti et de, legni. L'altra maniera si è, che io per me stimerei, che non fosse gran fatto disdicevole il credere, che quell' anima o quella virtù, la quale genera i fiori ed i frutti nelle piante viventi, sia quella stessa che generi ancora i bachi di esse piante. E chi sà forse, che molti frutti degli alberi non sieno prodotti, non per un fine primario e principale, ma bensi per un uffizio secondario e servile, destinato alla generazione di que' vermi, servendo a loro in vece di matrice, in cui dimorino un prefisso e determinato tempo; il quale arrivato escan fuora a godere il sole.

"Io m' immagino, che questo mio pensiero non vi parrà totalmente un paradosso; mentre farete riflessione a quelle tante sorte di galle, di gallozzole, di coccole, di ricci, di calici, di cornetti e di lappole, che son produtte dalle querce, dalle farnie, da' cerri, da' sugheri, da' lecci e da altri simili alberi da ghianda; imperciocchè in quelle gallozzole, e particolarmente nelle più grosse, che si chiamano coronati, ne' ricci capelluti, che ciuffoli da' nostri contadini son detti; nei ricci legnosi del cerro, ne' ricci stellati della quercia, nelle galluzze della foglia del leccio si vede evidentissimamente, che la prima e principale intenzione della natura è formare dentro di quelle un animale volante; vedendosi nel centro della gallozzola un uovo, che col crescere e col maturarsi di essa gallozzola va crescendo e maturando anch' egli, e cresce altresi a suo tempo quel verme che nell' uovo si racchiude; il qual verme, quando la gallozzola è finita di maturare e che è venuto il termine destinato al suo nascimento, diventa, di verme che era, una mosca. . . Io vi confesso ingenuamente, che prima d'aver fatte queste mie esperienze intorno alla generazione degl' insetti mi dava a credere, o per dir meglio sospettava, che forse la gallozzola nascesse, perchè arrivando la mosca nel tempo della primavera, e facendo una piccolissima fessura ne' rami più teneri della quercia, in quella fessura nascondesse uno de suoi semi, il quale fosse cagione che sbocciasse fuora la gallozzola; e che mai non si vedessero galle o gallozzole o ricci o cornetti o calici o coccole, se non in que' rami, ne' quali le mosche avessero depositate le loro semenze; e mi dava ad intendere, che le gallozzole fossero una malattia cagionata nelle querce dalle punture delle mosche, in quella guisa stessa che dalle punture d'altri animaletti simiglievoli veggiamo crescere de' tumori ne' corpi degli animali."

looked like mere dots and lines under the ordinary microscopes of the eighteenth century.

Led by various theoretical considerations which I cannot now discuss, but which looked promising enough in the lights of that day, Buffon and Needham doubted the applicability of Redi's hypothesis to the infusorial animalcules, and Needham very properly endeavoured to put the question to an experimental test. He said to himself, if these infusorial animalcules come from germs, their germs must exist either in the substance infused, or in the water with which the infusion is made, or in the superjacent air. Now the vitality of all germs is destroyed by heat. Therefore, if I boil the infusion, cork it up carefully, cementing the cork over with mastic, and then heat the whole vessel by heaping hot ashes over it, I must needs kill whatever germs are present. Consequently, if Redi's hypothesis holds good, when the infusion is taken away and allowed to cool, no animalcules ought to be developed in it; whereas, if the animalcules are not dependent on preexisting germs, but are generated from the infused substance, they ought, by-and-by, to make their appearance. Needham found that, under the circumstances in which he made his experiments, animalcules always did arise in the infusions, when a sufficient time had elapsed to allow for their development.

In much of his work Needham was associated with Buffon, and the results of their experiments fitted in admirably with the great French naturalist's hypothesis of "organic molecules," according to which, life is the indefeasible property of certain indestructible molecules of matter, which exist in all living things, and have inherent activities by which they are distinguished from not living matter. Each individual living organism is formed by their temporary combination. They stand to it in the relation of the particles of water to a cascade, or a whirlpool; or to a mould, into which the water is poured. The form of the organism is thus determined by the reaction between external conditions and the inherent activities of the organic molecules of which it is composed; and, as the stoppage of a whirlpool destroys nothing but a form, and leaves the molecules of the water with all their inherent activities intact, so what we call the death and putrefaction of an animal, or of a plant, is merely the breaking up of the form, or manner of association, of its constituent organic molecules, which are then set free as infusorial animalcules.

It will be perceived that this doctrine is by no means identical with *Abiogenesis*, with which it is often confounded. On this hypothesis, a piece of beef, or a handful of hay, is dead only in a limited sense. The beef is dead ox, and the hay is dead grass; but

fermentation and putrefaction. The question of the generation of the infusory animalcules thus passed into a new phase. For what might not have happened to the organic matter of the infusions, or to the oxygen of the air, in Spallanzani's experiments? What security was there that the development of life which ought to have taken place had not been checked, or prevented, by these changes?

The battle had to be fought again. It was needful to repeat the experiments under conditions which would make sure that neither the oxygen of the air, nor the composition of the organic matter, was altered, in such a manner as to interfere with the existence of life.

Schulze and Schwann took up the question from this point of view in 1836 and 1837. The passage of air through red-hot glass tubes, or through strong sulphuric acid, does not alter the proportion of its oxygen, while it must needs arrest, or destroy, any organic matter which may be contained in the air. These experimenters, therefore, contrived arrangements by which the only air which should come into contact with a boiled infusion should be such as had either passed through red-hot tubes, or through strong sulphuric acid. The result which they obtained was that an infusion so treated developed no living things, while if the same infusion was afterwards exposed to the air such things appeared rapidly and abundantly. The accuracy of these experiments has been alternately denied and affirmed. Supposing them to be accepted, however, all that they really proved was, that the treatment to which the air was subjected destroyed *something* that was essential to the development of life in the infusion.

This "something" might be gaseous, fluid, or solid; that it consisted of germs remained only an hypothesis of greater or less probability.

Contemporaneously with these investigations a remarkable discovery was made by Cagniard de la Tour. He found that common yeast is composed of a vast accumulation of minute plants. The fermentation of must, or of wort, in the fabrication of wine and of beer, is always accompanied by the rapid growth and multiplication of these *Torulæ*. Thus fermentation, in so far as it was accompanied by the development of microscopical organisms in enormous numbers, became assimilated to the decomposition of an infusion of ordinary animal or vegetable matter; and it was an obvious suggestion that the organisms were, in some way or other, the causes both of fermentation and of putrefaction. The chemists, with Berzelius and Liebig at their head, at first laughed this idea to scorn; but in 1843, a man then very young, who has since performed the unexampled feat of attaining to high eminence alike in Mathematics, Physics, and Phy-

nevertheless be a reality. He has demonstrated that ordinary air is no better than a sort of stirabout of excessively minute solid particles; that these particles are almost wholly destructible by heat; and that they are strained off, and the air rendered optically pure, by being passed through cotton-wool.

But it remains yet in the order of logic, though not of history, to show that, among these solid destructible particles, there really do exist germs capable of giving rise to the development of living forms in suitable menstrua. This piece of work was done by M. Pasteur in those beautiful researches which will ever render his name famous; and which in spite of all attacks upon them, appear to me now, as they did seven years ago,[1] to be models of accurate experimentation and logical reasoning. He strained air through cotton-wool, and found, as Schroeder and Dusch had done, that it contained nothing competent to give rise to the development of life in fluids highly fitted for that purpose. But the important further links in the chain of evidence added by Pasteur are three. In the first place, he subjected to microscopic examination the cotton-wool which had served as strainer, and found that sundry bodies, clearly recognizable as germs, were among the solid particles strained off. Secondly, he proved that these germs were competent to give rise to living forms by simply sowing them in a solution fitted for their development. And, thirdly, he showed that the incapacity of air strained through cotton-wool to give rise to life, was not due to any occult change effected in constituents of the air by the wool, by proving that the cotton-wool might be dispensed with altogether, and perfectly free access left between the exterior air and that in the experimental flask. If the neck of the flask is drawn out into a tube and bent downwards; and if, after the contained fluid has been carefully boiled the tube is heated sufficiently to destroy any germs which may be present in the air which enters as the fluid cools, the apparatus may be left to itself for any time, and no life will appear in the fluid. The reason is plain. Although there is free communication between the atmosphere laden with germs and the germless air in the flask, contact between the two takes place only in the tube; and as the germs cannot fall upwards, and there are no currents, they never reach the interior of the flask. But if the tube be broken short off where it proceeds from the flask, and free access be thus given to germs falling vertically out of the air, the fluid which has remained clear and desert for months, becomes, in a few days, turbid and full of life.

[1] "Lectures to Working Men on the Causes of the Phenomena of Organic Nature," 1863.

It is demonstrable, that the great majority of these particles are destructible by heat, and that some of them are germs, or living particles, capable of giving rise to the same forms of life as those which appear when the fluid is exposed to unpurified air.

It is demonstrable, that inoculation of the experimental fluid with a drop of liquid known to contain living particles gives rise to the same phenomena as exposure to unpurified air.

And it is further certain that these living particles are so minute that the assumption of their suspension in ordinary air presents not the slightest difficulty. On the contrary, considering their lightness and the wide diffusion of the organisms which produce them, it is impossible to conceive that they should not be suspended in the atmosphere in myriads.

Thus the evidence, direct and indirect, in favour of *Biogenesis* for all known forms of life must, I think, be admitted to be of great weight.

On the other side, the sole assertions worthy of attention are, that hermetically sealed fluids, which have been exposed to great and long-continued heat, have sometimes exhibited living forms of low organisation when they have been opened.

The first reply that suggests itself is the probability that there must be some error about these experiments, because they are performed on an enormous scale every day, with quite contrary results. Meat, fruits, vegetables, the very materials of the most fermentable and putrescible infusions, are preserved to the extent, I suppose I may say, of thousands of tons every year, by a method which is a mere application of Spallanzani's experiment. The matters to be preserved are well boiled in a tin case provided with a small hole, and this hole is soldered up when all the air in the case has been replaced by steam. By this method they may be kept for years, without putrefying, fermenting, or getting mouldy. Now this is not because oxygen is excluded, inasmuch as it is now proved that free oxygen is not necessary for either fermentation or putrefaction. It is not because the tins are exhausted of air, for *Vibriones* and *Bacteria* live, as Pasteur has shown, without air or free oxygen. It is not because the boiled meats or vegetables are not putrescible or fermentable, as those who have had the misfortune to be in a ship supplied with unskilfully closed tins well know. What is it, therefore, but the exclusion of germs? I think that Abiogenists are bound to answer this question before they ask us to consider new experiments of precisely the same order.

And in the next place, if the results of the experiments I refer to

of Biogenesis, which appears to me, with the limitations I have expressed, to be victorious along the whole line at the present day.

As regards the second problem offered to us by Redi, whether Xenogenesis obtains, side by side with Homogenesis; whether, that is, there exist not only the ordinary living things, giving rise to offspring which run through the same cycle as themselves, but also others, producing offspring which are of a totally different character from themselves, the researches of two centuries have led to a different result. That the grubs found in galls are no product of the plants on which the galls grow, but are the result of the introduction of the eggs of insects into the substance of these plants, was made out by Vallisnieri, Reaumur, and others, before the end of the first half of the eighteenth century. The tapeworms, bladderworms, and flukes continued to be a stronghold of the advocates of Xenogenesis for a much longer period. Indeed it is only within the last thirty years that the splendid patience of Von Siebold, Van Beneden, Leuckart, Küchenmeister, and other helminthologists has succeeded in tracing every such parasite, often through the strangest wanderings and metamorphoses, to an egg derived from a parent, actually or potentially like itself; and the tendency of inquiries elsewhere has all been in the same direction. A plant may throw off bulbs, but these sooner or later, give rise to seeds or spores, which develop into the original form. A polype may give rise to Medusæ, or a pluteus to an Echinoderm, but the Medusa and the Echinoderm give rise to eggs which produce polypes or plutei, and they are therefore only stages in the cycle of life of the species.

But if we turn to pathology it offers us some remarkable approximations to true Xenogenesis.

As I have already mentioned, it has been known since the time of Vallisnieri and of Reaumur, that galls in plants, and tumours in cattle, are caused by insects, which lay their eggs in those parts of the animal or vegetable frame of which these morbid structures are outgrowths. Again, it is a matter of familiar experience to everybody that mere pressure on the skin will give rise to a corn. Now the gall, the tumour, and the corn are parts of the living body, which have become, to a certain degree, independent and distinct organisms. Under the influence of certain external conditions, elements of the body, which should have developed in due subordination to its general plan, set up for themselves and apply the nourishment which they receive to their own purposes.

From such innocent productions as corns and warts, there are all gradations to the serious tumours which, by their mere size and

of infection and contagion to others, for precisely the same reason as a tub of fermenting beer is capable of propagating its fermentation by "infection," or "contagion," to fresh wort. In both cases it is the solid living particles which are efficient; the liquid in which they float, and at the expense of which they live, being altogether passive.

Now arises the question, are these microzymes the results of *Homogenesis*, or of *Xenogenesis*; are they capable, like the *Torulæ* of yeast, of arising only by the development of preexisting germs; or may they be, like the constituents of a nut-gall, the results of a modification and individualization of the tissues of the body in which they are found, resulting from the operation of certain conditions? Are they parasites in the zoological sense, or are they merely what Virchow has called "heterologous growths"? It is obvious that this question has the most profound importance, whether we look at it from a practical or from a theoretical point of view. A parasite may be stamped out by destroying its germs, but a pathological product can only be annihilated by removing the conditions which give rise to it.

It appears to me that this great problem will have to be solved for each zymotic disease separately, for analogy cuts two ways. I have dwelt upon the analogy of pathological modification, which is in favour of the xenogenetic origin of microzymes; but I must now speak of the equally strong analogies in favour of the origin of such pestiferous particles by the ordinary process of the generation of like from like.

It is, at present, a well-established fact that certain diseases, both of plants and of animals, which have all the characters of contagious and infectious epidemics, are caused by minute organisms. The smut of wheat is a well-known instance of such a disease, and it cannot be doubted that the grape-disease and the potato-disease fall under the same category. Among animals, insects are wonderfully liable to the ravages of contagious and infectious diseases caused by microscopic *Fungi*.

In autumn it is not uncommon to see flies, motionless upon a window-pane, with a sort of magic circle, in white, drawn round them. On microscopic examination the magic circle is found to consist of innumerable spores, which have been thrown off in all directions by a minute fungus called *Empusa muscæ*, the spore-forming filaments of which stand out like a pile of velvet from the body of the fly. These spore-forming filaments are connected with others, which fill the interior of the fly's body like so much fine wool, having eaten away and destroyed the creature's viscera. This is the full-grown condition

is built upon French silk, as much as Manchester was upon American cotton before the civil war.

Silkworms are liable to many diseases; and, even before 1853, a peculiar epizootic, frequently accompanied by the appearance of dark spots upon the skin (whence the name of "Pébrine" which it has received), had been noted for its mortality. But in the years following 1853 this malady broke out with such extreme violence, that in 1856, the silk-crop was reduced to a third of the amount which it had reached in 1853; and, up till within the last year or two, it has never attained half the yield of 1853. This means not only that the great number of people engaged in silk-growing are some thirty millions sterling poorer than they might have been; it means not only that high prices have had to be paid for imported silk-worm eggs, and that, after investing his money in them, in paying for mulberry-leaves and for attendance, the cultivator has constantly seen his silkworms perish and himself plunged in ruin,—but it means that the looms of Lyons have lacked employment, and that for years enforced idleness and misery have been the portion of a vast population which, in former days, was industrious and well to do.

In 1858 the gravity of the situation caused the French Academy of Sciences to appoint Commissioners, of whom a distinguished naturalist M. de Quatrefages, was one, to inquire into the nature of this disease, and, if possible, to devise some means of staying the plague. In reading the Report[1] made by M. de Quatrefages, in 1859, it is exceedingly interesting to observe that his elaborate study of the Pébrine forced the conviction upon his mind that, in its mode of occurrence and propagation, the disease of the silkworm is, in every respect, comparable to the cholera among mankind. But it differs from the cholera, and, so far, is a more formidable disease, in being hereditary, and in being, under some circumstances, contagious, as well as infectious.

The Italian naturalist, Filippi, discovered in the blood of the silkworms affected by this strange disease a multitude of cylindrical corpuscles, each about $\frac{1}{6000}$ of an inch long. These have been carefully studied by Lebert, and named by him *Panhistophyton*; for the reason that, in subjects in which the disease is strongly developed, the corpuscles swarm in every tissue and organ of the body, and even pass into the undeveloped eggs of the female moth. But are these corpuscles causes, or mere concomitants, of the disease? Some naturalists took one view and some another; and it was not until the French Government, alarmed by the continued ravages of the malady

[1] Etudes sur les Maladies Actuelles des Vers à Soie, p. 53.

Indeed there is already strong evidence that some diseases of an extremely malignant and fatal character to which man is subject are as much the work of minute organisms as is the Pébrine. I refer for this evidence to the very striking facts adduced by Professor Lister in his various well-known publications on the antiseptic method of treatment. It seems to me impossible to rise from the perusal of those publications without a strong conviction that the lamentable mortality which so frequently dogs the footsteps of the most skilful operator, and those deadly consequences of wounds and injuries which seem to haunt the very walls of great hospitals, and are, even now, destroying more men than die of bullet or bayonet, are due to the importation of minute organisms into wounds, and their increase and multiplication; and that the surgeon who saves most lives will be he who best works out the practical consequences of the hypothesis of Redi.

I commenced this Address by asking you to follow me in an attempt to trace the path which has been followed by a scientific idea in its long and slow progress from the position of a probable hypothesis to that of an established Law of Nature. Our survey has not taken us into very attractive regions; it has lain, chiefly, in a land flowing with the abominable, and peopled with mere grubs and mouldiness. And it may be imagined with what smiles and shrugs practical and serious contemporaries of Redi and of Spallanzani may have commented on the waste of their high abilities in toiling at the solution of problems which, though curious enough in themselves, could be of no conceivable utility to mankind.

Nevertheless you will have observed, that before we had travelled very far upon our road, there appeared, on the right hand and on the left, fields laden with a harvest of golden grain, immediately convertible into those things which the most sordidly practical of men will admit to have value—namely, money and life.

The direct loss to France caused by the Pébrine in seventeen years cannot be estimated at less than fifty millions sterling; and if we add to this what Redi's idea, in Pasteur's hands, has done for the wine-grower and for the vinegar-maker, and try to capitalize its value, we shall find that it will go a long way towards repairing the money losses caused by the frightful and calamitous war of this autumn.

And as to the equivalent of Redi's thought in life, how can we overestimate the value of that knowledge of the nature of epidemic and epizootic diseases, and consequently of the means of checking, or eradicating, them, the dawn of which has assuredly commenced?

XXXV

ON THE MILK DENTITION OF *PALÆOTHERIUM MAGNUM*

The Geological Magazine, vol. vii., 1870, *pp.* 153–155.

PLATE VI. [PLATE 30].

IN the British Museum there is the right ramus of the mandible of a young *Palæotherium magnum*, obtained by M. Bravard from the Eocene strata of Vaucluse, which possesses a peculiar interest, inasmuch as the three principal milk molars are completely cut, though their unworn crowns show that they have not long been in place. The ramus itself must have been nearly eight inches long when it was complete, while the distance from the articular surface of the condyle to the lower margin is about 3·25in. The symphysial surface is oval, rugose, and extends back nearly as far as the anterior margin of the crown of the first visible grinder; the anterior, or mental region of the ramus, is inclined upwards and forwards, and is slightly convex, as in all the true *Palæotheria*. In front of the most anterior milk molar which is in place, there is an oval fossa about 0·2in. long, which appears to lead into the alveolus of the proper first milk molar (*dm^1*); and further forward (but not more than 0·2in., so that the diastema of the milk teeth must have been exceedingly short) a series of depressions on the truncated anterior end of the ramus represent the bottoms of the alveoli of the canine and incisors.

The ramus of the mandible of an adult *Palæotherium magnum*, in the same collection, can hardly have been less than 15 inches long. The diastema between the small first grinding tooth and the great canine is about 0·8in. long, and the symphysis extends back to a little behind the anterior edge of *pm^2*.

The milk dentition of the Rhinoceroses and of the Horses is, at one period, in a condition which exactly corresponds with that of *Palæotherium magnum*. That is to say, the three posterior milk molars, dm^2, dm^3, dm^4, are in place and ready for use, while dm^1 remains in its alveolus, and is only cut very much later.

The foal differs from the young *Palæotherium* in the length of the crown of dm^2, which is as great as, if not greater than, that of the crowns of the other two milk molars; in the greater distance of the alveolus of dm^1 from dm^2, and in the much greater length of the diastema.

In the Rhinoceroses on the other hand (e.g. *Rh. indicus*) dm^2 is smaller in proportion to dm^3 than in the *Palæotherium*, and, if there were a canine tooth, the diastema would be as short as in the latter.

In the form of the ramus the Horse lies between the *Palæotherium* and the Rhinoceros.

It follows, from what has been stated, the rule which has been laid down for the *Ungulata* in general, that the crown of the last milk molar in the lower jaw always resembles that of the last true molar, does not hold good for *Palæotherium*. The genus *Paloplotherium* was founded upon the supposition that it did, and Pictet in the following passage very properly bases the distinctness of *Paloplothierum* from *Plagiolophus*, only on the ground that *Paloplotherium* is asserted to have no third lobe to its posterior lower molar.

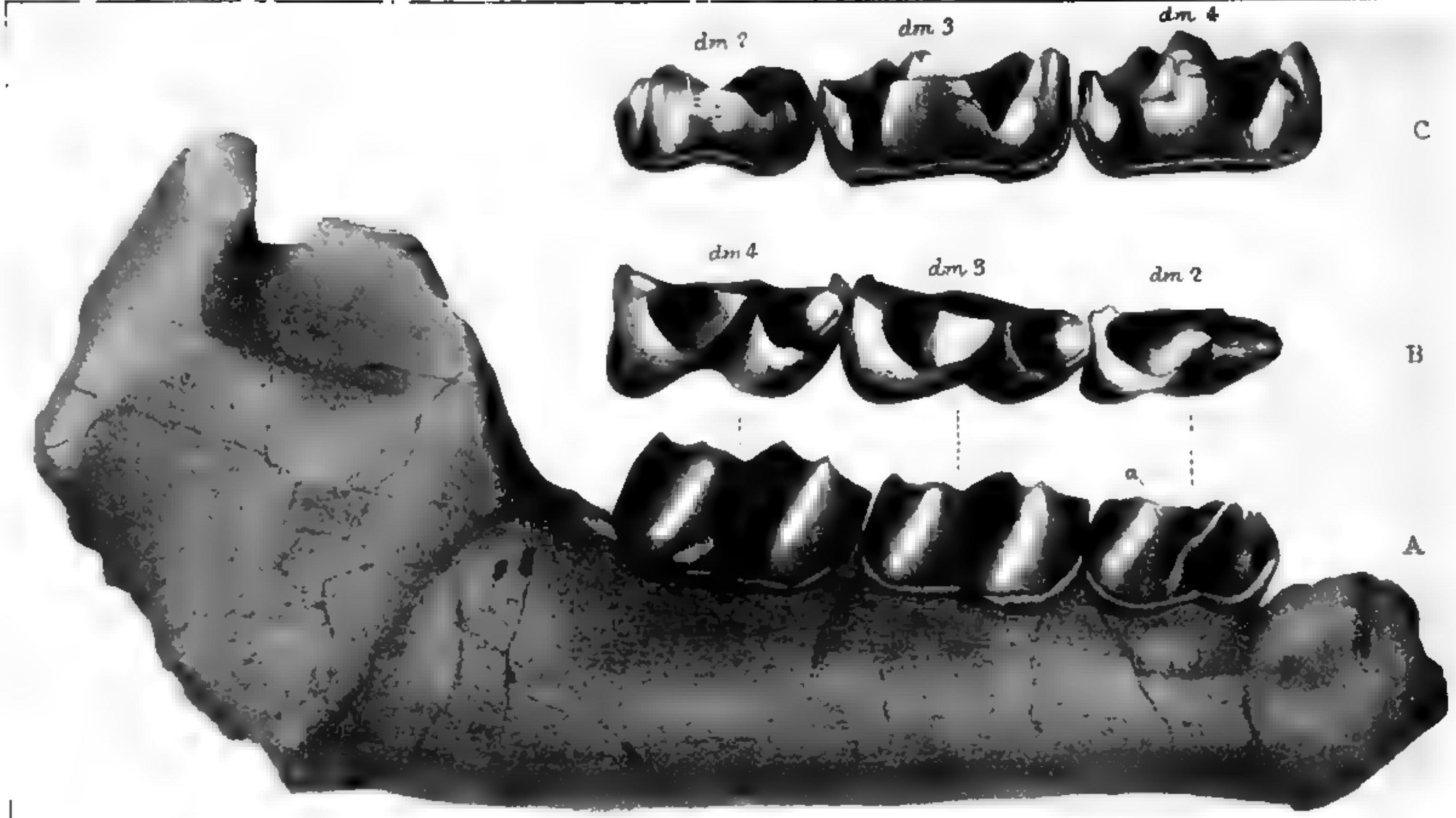
Il resulté de là:—1. Que le *P. minus* et le *P. annectens* se ressemblent par tout l'ensemble de leur dentition, et qu'ils different par plusieurs points essentiels des vrais *Palæotherium*.

2. Qu'ils se distinguent cependant l'un de l'autre par la forme de la dernière molaire inférieure, quë est à trois collines dans le premier et à deux dans le dernier.

3. Que le *P. annectens* doit en consequence former un sous genre spécial qui conserverait le nom de *Paloplotherium*, donné par M. Owen, et que le *P. minus* est le type d'un autre sous genre très voisin, mais distinct, auquel doit être attribué le nom de *Plagiolophus*, Pomel.[1]

The first volume of Pictet's "Paléontologie" was published in 1853. The "Mémoire" from which the extract just quoted is given, appeared in 1855; so that if M. Pictet rectified the character of *Paloplotherium* in the former year, he rectified his rectification in the latter.

[1] Mémoire sur les Animaux Vertébrés trouvés dans le Terrain siderilitique du canton de Vaud (p. 36).



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Palæotherium magnum Cuvier

XXXVI

TRIASSIC DINOSAURIA

Nature, vol. i., 1870, *pp.* 23, 24.

It will probably interest geologists and palæontologists to know that a recent examination of the numerous remains of *Thecodontosauria* in the Bristol Museum enables me to demonstrate that these Triassic reptiles belong to the order *Dinosauria*, and are closely allied to *Megalosaurus.* The vertebræ, humerus, and ilium, found in the Warwickshire Trias, which have been ascribed to *Labyrinthodon*, also belong to *Dinosauria.* The two skeletons obtained in the German Trias near Stuttgart, and described by Prof. Plieninger some years ago, are also unquestionable *Dinosauria* ; and, as Von Meyer is of opinion, probably belong to the genus *Teratosaurus*, from the same beds. Von Meyer's *Platæosaurus*, from the German Trias, is, plainly, as he has indicated it to be, a Dinosaurian.

As Prof. Cope has suggested, it is very probable that *Bathygnathus*, from the Triassic beds of Prince Edward's Island, is a Dinosaurian ; and I have no hesitation in expressing the belief that the *Deuterosaurus*, from the Ural, which occurs in beds which are called Permian, but which appear to be Triassic, is also a Dinosaurian. It is also very probable that *Rhopalodon*, which occurs in these rocks, belongs to the same order. If so, the close resemblance of the South African *Galesaurus* to *Rhopalodon* would lead me to expect the former to prove a Dinosaur.

I have found an indubitable fragment of a Dinosaurian among some fossils, not long ago sent to me, from the reptiliferous beds of Central India, by Dr. Oldham, the Director of the Indian Geological Survey. Further, the determination of the Thecodonts as *Dinosauria*, leaves hardly any doubt that the little *Ankistrodon* from these Indian rocks, long since described by me, belongs to the same group.

XXXVII

ON THE RELATIONS OF PENICILLIUM, TORULA, AND BACTERIUM.

Quarterly Journal of Microscopical Science, vol. x., new series, 1870, *pp.* 355–362. (*Special Report of an Address delivered in the Biological Section of the British Association for the Advancement of Science, September* 13*th,* 1870.)[1]

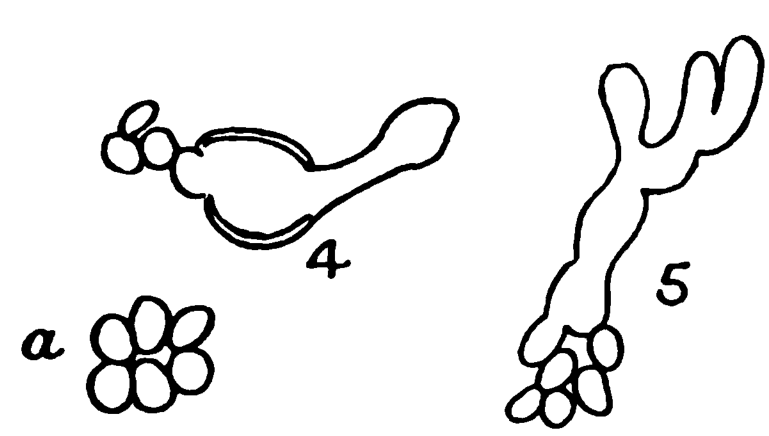
THE names Penicillium, Torula, and Bacterium are applied to exceedingly humble things. That which the scientific man terms Penicillium is popularly known as mould; Torula is the name given to yeast; whilst Bacterium is so minute that it has not attracted common attention, and hence has received no popular name. I propose to give a statement of what I imagine to be the relation of these three forms, from work which I have myself lately been carrying on; and I shall have to tell you of some very remarkable facts connected with their growth and development.

It is a fact familiar to every one here that mould makes its appearance on decaying matters. If you examine such a growth of mould, and take some of the finer powder-like matter from its surface, and placing this on a glass slide, apply a high power of the microscope, you observe that the grey powder which you have got on your slide consists of a vast number of small spheres, of various sizes, the biggest as large as the red corpuscles which are floating in my blood—some a great deal less, not more than the $\frac{1}{10000}$th of an inch in diameter, the average diameter being about $\frac{1}{7000}$th of an inch. Such a body is known as a spore or conidium. On applying pressure to the covering glass which you have placed on the slide, you may burst some of these spores, and you will find that each consists of a transparent coat or bag (Fig. 1), which appears to be composed of cellulose. In the interior of this coat is a delicate soft material, containing

[1] This report was written by Professor Lankester: it was not revised for press by Professor Huxley nor authorised by him, and he must not be considered as having deliberately promulgated the view as to the genetic connection of Torula and Bacteria which he entertained temporarily and formulated in this address.—E. R. L.

you place in this solution a minute grain of protoplasm, supply a certain amount of heat, and this little grain puts together the elements in that solution anew; it builds them into a living organism according to a type and pattern of its own. This is the first stage in the growth of this organism, the development of the spore or conidium into the mycelium. The mycelium is made up of these threads, which spring firstly from the spore and branch in various directions, and are called hyphæ. Each hypha has the same composition as the spore, being merely an elongated tube of cellulose with a mass of elongated protoplasm within, and it is continuous throughout. So long as this form of growth goes on the hyphæ are submerged in the fluid, or only floating near the surface; but after a time, in accordance with some change in the conditions of the fluid, one hypha will send up a vertical branch, which grows so as to stick up out of the water; and the aërial processes so formed are most difficult to wet, for they have the power of throwing off the water on account of the adherence of air to their surfaces. This vertical branch grows up and sends out three or more processes, which become constricted and broken up into little balls (fig. 3 *a*). All this takes place simply by prolongation; there are no cells in this matter; there may be partitions in the protoplasm, but there are no nuclei and no subdivision of such bodies. Each of the spherical bodies at the end of the aërial stalk at which we have arrived is a spore or conidium such as we started from, and one would think that this was a complete life-cycle. There is, however, a singular variety of other and secondary developments.

One of the commonest—I found them in all cases where I got the mycelium just described—I will now mention. When a conidium is developing and sending out its first hypha, it will frequently send out from the other side a moniliform process which breaks off and floats about (fig. 4). Sometimes each globule in these detached masses seems to have a nucleus. This (fig. 4 *a*) is the Torula form; it is the same as yeast, differing only in size in this particular case. If the conditions are favourable, absolutely the whole development of the spores or conidia may be Torulæ. The great condition which favours this is the absence of atmospheric air. It is an ascertained fact that this Torula form grows without oxygen and without light: this is a physiological fact of the highest importance, established by Pasteur, with regard to Penicillium-yeast. What is the fate of Torula? what



at the bottom of the mistakes made in the assertions as to the survival of Bacteria, &c., after the application of very high temperatures. I have made experiments with this matter in view. I boiled a solution containing living Bacteria for two hours. On searching for them after this, I found them unchanged in most respects, but somewhat firmer in texture, like salt beef on board ship after it is boiled. When treated with chromic acid, iodine, or strong alcohol, the Bacteria remain. Their life is undoubtedly destroyed by these reagents. Every one admits that; but there they remain with but a slight change of appearance. Do what you will, however, they retain their *trembling* movement; and this is a very misleading phenomenon. Dr. Bastian was good enough to unseal a flask in my presence, which had been closed at a temperature of 150° Centigrade; and I saw there and then Bacteria exhibiting these active, trembling movements, which, had they come from any other solution, I should have *then* considered as a proof of their being alive. But with regard to the other kind of movements, it is quite otherwise. On raising the liquid in which they are to the boiling-point, it stops at once, or if you add any of the reagents just now mentioned. The first kind of movement is no doubt the Brownian movement, first shown by Robert Brown to be exhibited by minute particles of a variety of substances, when placed in liquid. When you have a rod instead of a granule, vibration must act unequally, and hence come the curious, oscillatory, rotating movements of the elongated Bacteria. This discrimination is of the utmost importance. I cannot be certain about other persons, but I am of opinion that observers who have supposed they have found Bacteria surviving after boiling have made the mistake which I should have done at one time, and, in fact, have confused the Brownian movements with *true living* movements. So, according to my notion a fluid full of Bacteria, moving like Vibriones, and twisting about in various ways, does not necessarily contain anything alive at all.

How do these Bacteria come about? I speak with caution, in accordance with experiments by other persons, especially that excellent lady, the Frau Johanna Luders.[1] I have never examined yeast without finding Bacteria, and in a sessile state. You may see Bacteria sculling about, and then becoming quiet, and stuck all about in a perfectly motionless state, as though fixed in some substance. They are so; they are embedded in a jelly, like many other low organisms, especially Algæ; they exhibit this phenomenon of a quiescent stage, during which they are encased in gelatinous matter. Pouchet and others have supposed them to be dead, but Cohn showed

[1] See *Quarterly Journal of Microscopical Science*, vol. viii.

as soon believe that the calf I see grazing in a meadow, had been spontaneously generated from the grass and flowers there. In the second place, the discrimination of the modes of movement of bacteria is important. Thirdly, the development of living matter from mineral matter without the influence of light which I have mentioned above is of the highest importance. In relation to the life of the deep sea organisms it is important. We have had all sorts of speculations as to their life in the dark, my own included.[1] The mystery of Bathybius is paralleled by the protoplasmic material of Penicillium which develops in the dark in the same way as it does; just also as Penicillium turns ammoniacal salts in the dark into protoplasm, so may Bathybius do the same at the bottom of the sea, and so we need not trouble ourselves with any special hypothesis to account for the occurrence of a sheet of living matter in this position.

[After some discussion, Professor Huxley added, that he *never* had seen the true vital movements of Bacteria after they had been boiled. He admitted there were flaws in Pasteur's work on account of his having used only low powers of the microscope. The divergence between his (Professor Huxley's) views and that of abiogenesis was merely one of time. As a believer in the doctrine of evolution in its most extreme form, he believed that organic matter had at one time developed from mineral matter, but that was no reason why it should do so in the cases cited by abiogenists. He considered that all attempts at what the Germans call "rein-cultur" must be abandoned in working at the development of Bacteria, since it was impossible to obtain an optically pure specimen of water. He had never found a drop of water in which he could vouch for the absence of any particles the $\frac{1}{10000}$th of an inch in diameter, and it was particles of this size, the microzymes of some writers, which are the first appearance of Bacterium. If, as he mentioned in his inaugural address, you take an infusion of hay, and examine it *at once*, you find swarms of Bacteria, spores, &c.; if you now place it in two flasks A and B, then boil both and stop up A carefully with cotton wool while boiling, but leave B's mouth open, you will find after a few days, that whilst A only contains the original Bacteria—dead, having been killed by boiling, the flask B contains the dead ones and is milky with the development of fresh ones, which exhibit true vital movement. It is such dead Bacteria as exist in A, which by their Brownian movements have led to the assertion that living Bacteria develop after boiling in closed vessels.]

[1] See *Quarterly Journal of Microscopical Science*, October, 1868.

influence on the nervous system ; so that in small doses it exhilarates, while in larger it stupefies and may even destroy life.

Moreover, if the original fluid is put into a still, and heated for a while, the first and last product of its distillation is simple water ; while, when the altered fluid is subjected to the same process, the matter which is first condensed in the receiver is found to be a clear, volatile substance, which is lighter than water, has a pungent taste and smell, possesses the intoxicating powers of the fluid in an eminent degree, and takes fire the moment it is brought in contact with a flame. The alchemists called this volatile liquid, which they obtained from wine, "spirits of wine," just as they called hydrochloric acid "spirits of salt," and as we, to this day, call refined turpentine "spirits of turpentine." As the "spiritus," or breath, of a man was thought to be the most refined and subtle part of him, the intelligent essence of man was also conceived as a sort of breath, or spirit ; and, by analogy, the most refined essence of any thing was called its "spirit." And then it has come about that we use the same word for the soul of man and for a glass of gin.

At the present day, however, we even more commonly use another name for this peculiar liquid—namely, "alcohol," and its origin is not less singular. The Dutch physician, Van Helmont, lived in the latter part of the sixteenth and the beginning of the seventeenth century—in the transition period between alchemy and chemistry—and was rather more alchemist than chemist. Appended to his "Opera Omnia," published in 1707, there is a very needful "Clavis ad obscuriorum sensum referendum," in which the following passage occurs :—

"ALCOHOL.—Chymicis est liquor aut pulvis summè subtilisatus, vocabulo Orientalibus quoque, cum primis Habessinis, familiari, quibus *cohol* speciatum pulverem impalpabilem ex antimonio pro oculis tingendis denotat. . . . Hodie autem, ob analogiam quivis pulvis tenerior, ut pulvis oculorum caneri summè subtilisatus *alcohol* audit, haud aliter ac spiritus rectificatissimi *alcolisati* dicuntur."

Robert Boyle similarly speaks of a fine powder as "alcohol" ; and so late as the middle of the last century the English lexicographer, Nathan Bailey, defines "alcohol" as "the pure substance of anything separated from the more gross, a very fine and impalpable powder, or a very pure, well-rectified spirit." But, by the time of the publication of Lavoisier's "Traité Elémentaire de Chimie," in 1789, the term "alcohol," "alkohol," or "alkool" (for it is spelt in all three ways), which Van Helmont had applied primarily to a fine powder, and only secondarily to spirits of wine, had lost its primary meaning altogether,

the most certain, as well as the most expeditious, way of making a sweet juice ferment was to add to it a little of the scum, or lees, of another fermenting juice. And it can hardly be questioned that this singular excitation of fermentation in one fluid, by a sort of infection, or inoculation, of a little ferment taken from some other fluid, together with the strange swelling, foaming, and hissing of the fermented substance, must have always attracted attention from the more thoughtful. Nevertheless, the commencement of the scientific analysis of the phenomena dates from a period not earlier than the first half of the seventeenth century.

At this time, Van Helmont made a first step, by pointing out that the peculiar hissing and bubbling of a fermented liquid is due, not to the evolution of common air (which he, as the inventor of the term "gas," calls "gas ventosum"), but to that of a peculiar kind of air such as is occasionally met with in caves, mines, and wells, and which he calls "gas sylvestre."

But a century elapsed before the nature of this "gas sylvestre," or as it was afterwards called, "fixed air," was clearly determined, and it was found to be identical with that deadly "choke damp" by which the lives of those who descend into old wells, or mines, or brewers' vats, are sometimes suddenly ended; and with the poisonous aeriform fluid which is produced by the combustion of charcoal, and now goes by the name of carbonic acid gas.

During the same time it gradually became clear that the presence of sugar was essential to the production of alcohol and the evolution of carbonic acid gas, which are the two great and conspicuous products of fermentation. And finally, in 1787, the Italian chemist, Fabroni, made the capital discovery that the yeast ferment, the presence of which is necessary to fermentation, is what he termed a "vegeto-animal" substance—or is a body which gives off ammoniacal salts when it is burned, and is, in other ways, similar to the gluten of plants and the albumen and casein of animals.

These discoveries prepared the way for the illustrious Frenchman, Lavoisier, who first approached the problem of fermentation with a complete conception of the nature of the work to be done. The words in which he expresses this conception, in the treatise on elementary chemistry, to which reference has already been made, mark the year 1789 as the commencement of a revolution of not less moment in the world of science than that which simultaneously burst over the political world, and soon engulfed Lavoisier himself in one of its mad eddies.

"We may lay it down as an incontestable axiom that, in all the

investigation of the products of fermentation by Pasteur, in 1860 proved that this is not exactly true, and that there is a deficit of from 5 to 7 per cent. of the sugar which is not covered by the alcohol and carbonic acid evolved. The greater part of this deficit is accounted for by the discovery of two substances, glycerine and succinic acid, of the existence of which Lavoisier was unaware, in the fermented liquid. But about 1½ per cent. still remains to be made good. According to Pasteur, it has been appropriated by the yeast but the fact that such appropriation takes place cannot be said to be actually proved.

However this may be, there can be no doubt that the constituent elements of fully 98 per cent. of the sugar which has vanished during fermentation have simply undergone rearrangement: like the soldiers of a brigade, who at the word of command divide themselves into the independent regiments to which they belong. The brigade is sugar, the regiments are carbonic acid, succinic acid, alcohol and glycerine.

From the time of Fabroni onwards, it has been admitted that the agent by which this surprising rearrangement of the particles of the sugar is effected is the yeast. But the first thoroughly conclusive evidence of the necessity of yeast for the fermentation of sugar was furnished by Appert, whose method of preserving perishable articles of food excited so much attention in France at the beginning of this century. Gay-Lussac, in his "Mémoire sur la Fermentation,"[1] alludes to Appert's method of preserving beer-wort unfermented for an indefinite time, by simply boiling the wort and closing the vessel in which the boiling fluid is contained, in such a way as thoroughly to exclude air; and he shows that, if a little yeast be introduced into such wort, after it has cooled, the wort at once begins to ferment, even though every precaution be taken to exclude air. And this statement has since received full confirmation from Pasteur.

On the other hand, Schwann, Schroeder and Dusch, and Pasteur, have amply proved that air may be allowed to have free access to beer-wort, without exciting fermentation, if only efficient precautions are taken to prevent the entry of particles of yeast along with the air.

Thus, the truth that the fermentation of a simple solution of sugar in water depends upon the presence of yeast, rests upon an unassailable foundation; and the inquiry into the exact nature of the substance which possesses such a wonderful chemical influence becomes profoundly interesting.

The first step towards the solution of this problem was made two

[1] "Annales de Chimie," 1810.

ceeded in verifying these statements; and my own observations lead me to believe, that while the connection between *Torula* and the moulds is a very close one, it is of a different nature from that which has been supposed. I have never been able to trace the development of *Torula* into a true mould; but it is quite easy to prove that species of true mould, such as *Penicillium*, when sown in an appropriate nidus, such as a solution of tartrate of ammonia and yeast-ash in water, with or without sugar, give rise to *Torulæ*, similar in all respects to *T. cerevisiæ*, except that they are, on the average, smaller. Moreover, Bail has observed the development of a *Torula* larger than *T. cerevisiæ*, from a *Mucor*, a mould allied to *Penicillium*.

It follows, therefore, that the *Torulæ*, or organisms of yeast, are veritable plants; and conclusive experiments have proved that the power which causes the rearrangement of the molecules of the sugar is intimately connected with the life and growth of the plant. In fact, whatever arrests the vital activity of the plant also prevents it from exciting fermentation.

Such being the facts with regard to the nature of yeast, and of the changes which it effects on sugar, how are they to be accounted for? Before modern chemistry had come into existence, Stahl, stumbling with the stride of genius, upon the conception which lies at the bottom of all modern views of the process, put forward the notion that the ferment, being in a state of internal motion, communicated that motion to the sugar, and thus caused its resolution into new substances. And Lavoisier, as we have seen, adopts substantially the same view. But Fabroni, full of the then novel conception of acids and bases and double decompositions, propounded the hypothesis that sugar is an oxide with two bases and the ferment a carbonate with two bases; that the carbon of the ferment unites with the oxygen of the sugar, and gives rise to carbonic acid; while the sugar, uniting with the nitrogen of the ferment, produces a new substance analogous to opium. This is decomposed by distillation, and gives rise to alcohol. Next, in 1803, Thénard propounded a hypothesis which partakes somewhat of the nature of both Stahl's and Fabroni's views. "I do not believe with Lavoisier," he says, "that all the carbonic acid formed proceeds from the sugar. How, in that case, could we conceive the action of the ferment on it? I think that the first portions of the acid are due to a combination of the carbon of the ferment with the oxygen of the sugar, and that it is by carrying off a portion of oxygen from the last that the ferment causes the fermentation to commence—the equilibrium between the principles of the sugar being disturbed, they combine afresh to form carbonic acid and alcohol."

able, the fact that the *Torulæ* are alive, and that yeast does not excite fermentation unless it contains living *Torulæ*, stands fast. Moreover, of late years the essential participation of living organisms in fermentation other than the alcoholic, has been clearly made out by Pasteur and other chemists.

However, it may be asked is there any necessary opposition between the so-called "vital" and the strictly physico-chemical views of fermentation? It is quite possible that the living *Torula* may excite fermentation in sugar, because it constantly produces, as an essential part of its vital manifestation, some substance which acts upon the sugar, just as the synaptase acts upon the amygdalin. Or it may be, that, without the formation of any such special substance, the physical condition of the living tissue of the yeast plant is sufficient to effect that small disturbance of the equilibrium of the particles of the sugar, which Lavoisier thought sufficient to effect its decomposition.

Platinum in a very fine state of division—known as platinum black, or *noir de platine*—has the very singular property of causing alcohol to change into acetic acid with great rapidity. The vinegar plant, which is closely allied to the yeast plant, has a similar effect upon dilute alcohol, causing it to absorb the oxygen of the air, and become converted into vinegar; and Liebig's eminent opponent, Pasteur, who has done so much for the theory and the practice of vinegar-making, himself suggests that in this case—

"La cause du phénomène physique qui accompagne la vie de la plante réside dans un état physique propre, analogue à celui du noir de platine. Mais il est essentiel de remarquer que cet état physique de la plante est étroitement lié avec la vie de cette plante." [1]

Now if the vinegar plant gives rise to the oxidation of alcohol, on account of its merely physical constitution, it is at any rate possible that the physical constitution of the yeast plant may exert a decomposing influence on sugar.

But, without presuming to discuss a question which leads us into the very arcana of chemistry, the present state of speculation upon the *modus operandi* of the yeast plant in producing fermentation is represented, on the one hand, by the Stahlian doctrine, supported by Liebig, according to which the atoms of the sugar are shaken into new combinations, either directly by the *Torulæ*, or indirectly, by some substance formed by them; and, on the other hand, by the Thénardian doctrine, supported by Pasteur, according to which the yeast plant assimilates part of the sugar, and in so doing, disturbs the rest, and

[1] "Etudes sur les Mycodermes," Comptes-Rendus, liv., 1862.

towards a definite end only by certain harmony among these units or by the superaddition of a controlling apparatus, such as a nervous system, this conception ceased to be tenable. The cell lives for its own sake, as well as for the sake of the whole organism; and the cells, which float in the blood, live at its expense, and profoundly modify it are almost as much independent organisms as the *Torulæ* which float in beer-wort.

Schwann burdened his enunciation of the "cell theory" with two false suppositions; the one, that the structures he called "nucleus" and "cell-wall" are essential to a cell; the other, that cells are usually formed independently of other cells; but, in 1839, it was a vast and clear gain to arrive at the conception, that the vital functions of all the higher animals and plants are the resultant of the forces inherent in the innumerable minute cells of which they are composed, and that each of them is, itself, an equivalent of one of the lowest and simplest of independent living beings—the *Torula*.

From purely morphological investigations, Turpin and Schwann, as we have seen, arrived at the notion of the fundamental unity of structure of living beings. And, before long, the researches of the chemists gradually led up to the conception of the fundamental unity of their composition.

So far back as 1803, Thénard pointed out, in most distinct terms, the important fact that yeast contains a nitrogenous "animal" substance; and that such substance is contained in all ferments. Before him, Fabroni and Fourcroy speak of the "vegeto-animal" matter of yeast. In 1844 Mulder endeavoured to demonstrate that a peculiar substance, which he called "protein," was essentially characteristic of living matter.

In 1846, Payen writes:—

"Enfin, une loi sans exception me semble apparaître dans les faits nombreux que j'ai observés et conduire à envisager sous un nouveau jour la vie végétale; si je ne m'abuse, tout ce que dans les tissus végétaux la vue directe où amplifiée nous permet de discerner sous la forme de cellules et de vaisseaux, ne représente autre chose que les enveloppes protectrices, les réservoirs et les conduits, à l'aide desquels les corps animés qui les secrètent et les façonnent, se logent, puisent et charrient leurs alimens, déposent et isolent les matières excrétées."

And again—

"Afin de compléter aujourd'hui l'énoncé du fait général, je rappellerai que les corps, doué des fonctions accomplies dans les tissus des plantes, sont formés des élémens qui constituent, en proportion peu variable, les organismes animaux; qu'ainsi l'on est

in my lecture "On the Physical Basis of Life," there was nothing new; and, as I hope, nothing that the present state of knowledge does not justify us in believing to be true. Under these circumstances, my surprise may be imagined, when I found, that the mere statement of facts and of views, long familiar to me as part of the common scientific property of continental workers, raised a sort of storm in this country, not only by exciting the wrath of unscientific persons whose pet prejudices they seemed to touch, but by giving rise to quite superfluous explosions on the part of some who should have been better informed.

Dr. Stirling, for example, made my essay the subject of a special critical lecture,[1] which I have read with much interest, though, I confess, the meaning of much of it remains as dark to me as does the "Secret of Hegel" after Dr. Stirling's elaborate revelation of it. Dr. Stirling's method of dealing with the subject is peculiar. "Protoplasm" is a question of history, so far as it is a name; of fact, so far as it is a thing. Dr. Stirling has not taken the trouble to refer to the original authorities for his history, which is consequently a travesty; and, still less, has he concerned himself with looking at the facts, but contents himself with taking them also at second-hand. A most amusing example of this fashion of dealing with scientific statements is furnished by Dr. Stirling's remarks upon my account of the protoplasm of the nettle hair. That account was drawn up from careful and often-repeated observation of the facts. Dr. Stirling thinks he is offering a valid criticism, when he says that my valued friend Professor Stricker gives a somewhat different statement about protoplasm. But why in the world did not this distinguished Hegelian look at a nettle hair for himself, before venturing to speak about the matter at all? Why trouble himself about what either Stricker or I say, when any tyro can see the facts for himself, if he is provided with those not rare articles, a nettle and a microscope? But I suppose this would have been "*Aufklärung*"—a recurrence to the base common-sense philosophy of the eighteenth century, which liked to see before it believed, and to understand before it criticised. Dr. Stirling winds up his paper with the following paragraph:—

"In short, the whole position of Mr. Huxley, (1) that all organisms consist alike of the same life-matter, (2) which life-matter is, for its part, due only to chemistry, must be pronounced untenable—nor less untenable (3) the materialism he would found on it."

The paragraph contains three distinct assertions concerning my

[1] Subsequently published under the title of "As Regards Protoplasm."